The Journal
OF THE
Royal United Service Institution.

VOL. V. 1861. No. XVII.

Evening Meeting.

Monday, March 4th, 1861.

Captain E. G. FISHBOURNE, R.N. C.B. in the Chair.

IRON-CASED SHIPS.

EXPERIMENTS AT WOOLWICH, 1845, AND ON "RUBY" AT PORTSMOUTH, 1856. SPHERICAL SHOT ONLY.

By CAPTAIN E. PELLEW HALSTED, R.N.

[It being inconsistent with the objects of the Institution that political matter should be introduced into the Journal, certain portions of Captain Halsted's Lectures have been omitted. It is however right, in justice to Captain Halsted, to state, that the various remarks excised are deemed by him to be essential to a clear understanding of the position in which the subject of Iron-cased Ships now stands, and of the causes which have led to it, and also for the purpose of enabling him to avoid the appearance of casting blame, where no such intention existed.—ED.]

BEFORE proceeding with the Lecture which you now do me the honour to attend, I have to acquit myself of a pledge, by stating that whatever views and opinions I may therein put forth are entirely independent of all connection, or known coincidence, with those of any Authority whatever, and that all responsibility for them rests upon myself alone. This statement will, however, at once suggest to you that these Lectures have not been undertaken without a previous intimation to the heads of my profession; a fact which I acknowledge the more readily, because the entire assent with which the announcement of my intention to deliver them was met may, I trust, be taken as an acknowledgement of the public advantage of affording both a freer access to special points of official information, and of promoting a more general discussion on important changes and improvements in the two Services, than has hitherto been possible under a system of almost mysterious Exclusiveness, the evils of which will, as I believe, receive strong illustration in the facts I am about to lay before you.

But, in order to reconcile my disclaimer with the very nature of the

drawings and specimens ranged before you, I feel it necessary to add, that my own official share in the trials on the "Trusty" off Shoeburyness, ceased entirely so soon as I had fulfilled my instructions to prepare the vessels to be employed in them; and it was quite a matter of choice with me whether I then left the harbour of Sheerness to witness them or not. I did so choose, however, and moreover made every pre-arrangement for recording with exactitude whatever I might witness, providing myself for this purpose with a correct drawing, "to scale," of the ship to be fired at, on which to lay off the exact position and effects of each shot as it was fired; all of which was done as is now presented in the illustration B, plate I. But it was never intended by me to do this for my own professional information alone; and accordingly, when the trials ceased, the Committee, who alone has conducted them throughout, were pleased to accept my offer to furnish them with a fair copy of the drawing thus produced, on which the facts, as indisputably agreed to at the time, had all been duly noted. To what use the copy thus furnished to the Committee may have been employed, I have ever since felt it a duty not even to inquire; but it is my own intention, through the medium of these Lectures, to furnish, as generally as I can to all my countrymen, a correct copy of the drawing then made for myself, as a first proof of the desirableness that, at every important National experiment, more than one set of views and opinions should be represented. At that time, however, it never crossed my mind that a series of plain facts, deliberately impressing themselves for two consecutive days on every sense but that of taste, of some 150 gentlemen, officers, men, and boys, could be made a subject for such directly opposite conclusions, as to require that detailed explanation, which, by aid of these drawings, I shall be enabled to give.

Of the "specimens" displayed, some I may describe as *derelicts*, being fragments of different sorts, left on the deck, or in the sides of the "Trusty," after the action, and taken possession of by me, as their most natural *curator*, to be held in deposit until claimed publicly or privately, by some more lawful possessor. For the loan of the Whitworth 80-pounder bolt, I am indebted to the ready kindness of that gentleman, as I am to the Admiralty for the fragment of the plate on which it so remarkably displayed its power. To the same Authority I am also indebted for one of the fastening bolts which received punishment; and I hereby express my sincere thanks to the Ordnance Committee for the loan of the steel 80-pounder shot of Sir William Armstrong.

But I must again appeal to your forbearance while I state, in as few words as possible, my reasons for not proceeding at once to the details and explanations on the trials of the "Trusty." The more I have sought, by careful investigation of all surrounding facts, to make my task satisfactory to others as well as myself, the more I have found it impossible with any regard to candour, or even truth, to treat this subject of "Iron-cased ships" as that of an isolated and recent invention; on the contrary, the closer I have examined, the more clearly have I seen that I had to deal with a complete chain of connected events, of which "Iron-cased ships" was but the latest link yet forged, and by no means likely to prove, in its present shape, the last one; and that forcibly to separate this link from those which had gone to produce it, as well as from those it was likely to produce, was an effort the futility of which must meet me at every step of my progress, even if I could have found it my duty to make it at all I

therefore felt that I had no alternative but either to decline to the Council of this Institution the invitation to lecture which I had already accepted, or to take up the subject link by link, from what may be termed "the first flotation of iron," down to the great question of the present day. And if, in following this latter course, I may unwillingly inflict disappointment on any, I would entreat those who may so feel, to give weight to the following considerations, which, in truth, lie at the base of that deep and sudden interest so largely called forth throughout our entire community on this whole subject.

Of all the material gifts bestowed on our Country, none has been so profusely and widely distributed,—none has so directly and permanently conduced to our national greatness,—as what, from their constant contiguity, may be termed our "combined" deposits of iron and coal; while to the great Country from which we are separated by so narrow a strait, these gifts have, in an equally remarkable manner, been so nearly denied altogether, as to make a freer access to—our—stores an undoubted and prominent object in the Treaty of intercourse which has lately been completed between us. How comes it then that, out of these materials, thus so unequally bestowed, France has been allowed to take an undisputed lead in the forging of a new and most formidable engine of Naval Force, so as to present the most serious threat ever yet made,—pacifically,—against that Supremacy in Naval Power by the security of which, under Providence, this insular and commercial Empire alone exists?

Is it that our People have been unaware that the materials, so rich in other blessings, could also be employed most largely to increase all international intercourse upon the ocean?

Is it that it never occurred to our Rulers that the same material which could so largely be employed as a means to increase our commerce, might also be used in the construction of those ships by which that commerce must be defended?

Or is it indeed that, after full and conclusive proofs, the anomaly in God's Providence has been clearly established, that the iron which may be used to construct whole fleets for the merchant, is entirely unfit for employment in any single vessel of war?

These inquiries, and especially the latter, will, I am sure, be seen to be far from irrelevant to the subject which has called us together; and, if traced out with that clearness and conciseness which I can scarcely even hope to attain, they must, I feel, impart an increased usefulness and force to the remainder of our common task. May not the examination of them direct us to such errors as may have induced our present anxious position?—and may not the discovery of these, ensure us a safer path of progress for the future?

These are results, any realization of which must be left to the joint judgment of all to whom these Lectures may come, but in no degree can any such results be even hoped for, except by a faithful investigation, followed out into all those scenes and changes, wheresoever enacted, which have indeed so largely contributed to bring the whole subject to its present state. In following this course, however, I purpose laying myself under close interdict against the mention of all names,—so far as is compatible with intelligible statements,—my object being, not to promote a renewal of past differences, but rather to invite to one common effort for

regaining that position which those differences have lost for us; at the same time seeking for, and laying bare, what I may conscientiously feel to be necessary truth, as the treatment alone worthy of a matter so serious in itself, and in the consequences it has involved.

More than thirty years have elapsed since the first discovery that "Ships built of iron float lighter, strength for strength, than ships built of wood;" and the merit of making this discovery,—and the practical prosecution of it,—and all the consequences now flowing, and still destined to flow, from it,—undoubtedly belong to the People of England. But, beyond this, I am far from pretending to fix either the locality or individual,—even if the merit can indeed be exclusively laid claim to, for any one person or place. Liverpool, however, would certainly rank high in any competition for the honour; and the name of her late citizen Mr. John Laird would be generally accepted as that of one, at least, of the Fathers of Iron shipbuilding: as will be his present successor, as one of its ablest sons.

But I leave in more competent hands this question of priority, and proceed to observe that this discovery at once gave rise to a distinctly new Art and Profession amongst us; the great natural laws which rule the necessary conditions of all safe locomotion on the ocean being alone of common authority over ships of iron and ships of wood;—all other conditions, such as strength, form, size, &c. being governed in each case by the entirely different nature and properties of the materials used. Thus the practical studies, as well as the scientific research, of the Shipbuilder in iron and the Shipbuilder in wood are necessarily engaged in spheres quite as distinct and diverse as those which, in a less degree, separate the occupation of the Carpenter from that of the Blacksmith; but, as the labours of both compete for the production of the same article, and as the Carpenter, so to speak, had long possessed an exclusive supply of the market,—and as even the tree which he best liked to use had fixed its roots deep in the soil of our national pride,—so it is no wonder if the progress of his more modern competitor should have been comparatively slow, though it has always been constant. This rate of progress will also appear the more inevitable, when it is considered to how large an extent the "plant" requisite in the two professions must entirely differ, not only in material and machinery, but in the skilled labour required to employ them, so that, except in the important items of "docks" and "slips,"—if suitable,—the loss of capital in transforming a building establishment for ships of wood into one for ships of iron, must, in all but very special cases, have been such as seriously to deter from any such changes, and the rivalry would thus assume the conditions, commercially, of a life and death struggle: and, if we further take into account the large amount of very natural prejudice, and I may add natural ignorance too, among all the larger masses affected by the new introduction, we shall have gathered into the same scale such an amount of adverse circumstances, as could alone be outweighed at all, by very great and intrinsic advantages.

But, before enumerating these advantages, I may be allowed to illustrate the great practical differences I have pointed to, by a brief analysis of those fundamental processes, with which the several parts of a ship of wood and a ship of iron are respectively bonded together, under the distinct operations of "bolting" in the one case, and "riveting" in the other. In the "bolting" of a ship of wood, it is not even proposed to bring contiguous, surfaces so closely together as to exclude the water; and

the dubbing of the adze,—not the smoothing of the plane,—is employed to produce that rough approach to a true surface which, whether on the sides of planks or of timbers, is all that is required in order that the "bolting" may proceed. The grip or bond of each bolt, by which, as a rule, the parts connected are made to feel its power to confine them together, has to be produced in full effect,—not at the time of "driving,"—but subsequently to it,—by means of a second, and distinct, though equally necessary, process,—that namely of "caulking;"—which consists in forcing with a fine-ended wedge and hammer the substance of "oakum" between the imperfect surfaces of the bolted parts, and thus, by great mechanical power, driving asunder to a degree those same parts, which the strength of the bolt,—by means of its "head" on the one side,—and its "clinched ring" on the other,—*equally* insists on holding together. When these two counter-processes are thus brought into conflict, under the favourable circumstances of well-executed work, on well-seasoned timber, &c., I need not, as a Seaman, expatiate on the solidity of the entire fabric which is thereby produced. But it is evident from its very nature, that the counter-power of the "caulking" can only be obtained by the use of some flexible and elastic material, such as hemp; and it is equally obvious that this again must be the first to yield, whenever the "working" of heavy ships in heavy weather, or any other sufficient cause, begins to give motion to the several parts of the fabric thus compacted together;—and to which motion of the integral parts, there is an inseparable tendency in every motion of the ship herself. In all such cases recourse can only be had to a repetition of the process, so soon as practicable; for the inconvenience of leakage arising from "loose caulking" is but a slight evil compared with the amount of "play," thereby permitted gradually to take place among the several component parts of the ship, and which, if allowed to progress, must, on each recurrence, or on the continuance, of the producing cause, render the ship less and less able to maintain her safety as a sea-boat. Thus the primary bond by which the entire fabric of a ship of wood is held safely together, is seen to depend on a compound of two equally essential processes, one of which has to be performed with materials of a nature so frail and perishable that, even with all the protection afforded by the application of pitch and resin, its repetition is a matter of frequent necessity; and, so completely does this appear to be an inevitable condition in all such structures, that no progress of art has yet succeeded in materially improving it, since the first great floating fabric sustained upon the face of the waters was, by Divine direction, required to be "pitched within and without."

The process of binding together the several parts of a ship of iron by the operation of "riveting" is in all respects very different, and far simpler. The parts to be joined are truly surfaced, though not polished. —The material which connects them is identical with that of which themselves are composed.—The rivet when applied, being soft with heat, is made almost to incorporate itself into the two parts it secures together;—and its perfect grip is thus ensured by one of the greatest powers with which nature has endowed metallic substances, that, namely, of Contraction after heating. If rivet-heads be protected as fully, both inboard and outboard, as they may and ought in every case to be, the process has never to be repeated, and the joint thus made is, in some respects, even

stronger than the separate parts which go to make it. A cold chisel, employed to "burr" the exposed edges of the joint, precludes all leakage. And it is the complete efficiency of this process, which is put to proof by hydraulic pressure in the case of every Naval steam boiler;—and may be seen every day in that of every Locomotive;—withstanding the subtlest effort of the highest steam used.

May not this comparison of the two modes of respectively bonding together, Ships of wood, and Ships of iron, suggest a further important difference as to their relative capacities for sustaining, during the emergencies of war, the prolonged stress of great weights of artillery, added to the continued effort of from 2,000 to 5,000 steam horses working a heavy vibrating propeller with great rapidity in their very extreme? How often in our wooden fabrics, under such circumstances, will the necessity for "re-caulking" be extended into a necessity for—Repair?

The acknowledged advantages which are possessed by England to a greater degree than by any other country, in the superiority of iron over wood as a material for the construction of ships, may be expressed under the following items:—

1. Greater facility for procuring, selecting, and maintaining throughout the fabric, any requisite standard of strength in the material used; without any process of "seasoning," and with a certainty unattainable with any wood.
2. Greater facility in producing any Form, however finely modified.
3. Greater facility for combining a maximum of strength, with a minimum of material.
4. Complete adaptability to vessels of every size.
5. Greater facility of imparting "strength of material" to every subordinate portion, and in every direction throughout the structure.
6. Greater lightness with equal strength.
7. Greater roominess in ships of equal external dimensions.
8. Shorter period required for construction.
9. Less expense, tonnage for tonnage, in all larger-sized ships.
10. Greater durability.
11. Less liability to repair, and far greater facility for it when required.
12. Superior security against the effects of leakage,—however caused,—and also against fire,—by the great facility of employing watertight bulk-heads, partial or complete, longitudinal or transverse, in any number, and for any purpose, considered requisite.

Against these advantages two serious drawbacks have to be stated, both of them connected with the very nature of iron. First, the property of the ship herself to falsify the indication of her Compasses, an effect, which in practice, has now been entirely obviated. And secondly, the great and rapid fouling of the ship's bottom, due to the facility for adhesion, offered to every marine substance, by the surface of every material yet applied for the protection of the bottom from corrosion; and this objection,—costing its annual tens of thousands among all concerned,—remains to the present day; no serious effort having as yet, to our great discredit, been made to remove it,—principally, as I believe, from causes hereafter to be stated.

The following facts will briefly substantiate some of the advantages stated.

In 1839 the well-known "Nemesis" ran on a rock off the Land's-end and entirely filled her fore-compartment level with the water; she was steamed into Mount's Bay, where she procured an additional pump, by the aid of which the compartment was cleared of water, and the leak secured,—before going into harbour. Twice subsequently, when on service in China, the same vessel was again saved by her bulkheads.

For sixteen years Her Majesty's well-known yacht "Fairy" has been at work, with a form as perfect, and a speed as high, as when first built in 1844.

The "Rainbow" steam-packet has now been constantly running on one station or another for twenty-five years, and is still earning good wages, her form unchanged, and her speed,—as affected by change of form,—still undiminished. And whenever the hull of the "Himalaya" shows the effects of fair "wear and tear," it may be well to note the amount of work in all climates which has produced it.

I need scarcely to mention the strength and tenacity of material, displayed by the effects of the "Great Britain's" uneasy winter's residence on the shore of Dundrum Bay.

In the destruction of the after-portion of the "Sarah Sands" by fire and explosion, on the 17th of November, 1857, an unanswerable evidence was given of the security afforded by ships of iron against fire; which may well demand consideration in its bearings on the probable future of wooden ships of war,—when under the fire of incendiary and explosive shells.

What other material than iron could have produced the vessel of 377 feet in length, 46 feet beam, and a "builder's measurement" of 3,900 tons, which on the 25th of January last steamed her 10½ knots in the Thames, with a displacement of 739 tons, on a draft of two feet water;—in preparation for her future Transport service on the Indus?

And, lastly, what timber could have produced that wondrous structure, which the true instinct of the whole Nation still regards with so much pride, though at present tinged with temporary disappointment? For the greater portion of ninety days the "Great Eastern," then weighing 12,000 tons, was suspended high and dry on her two cradles, 110 feet apart; only 240, out of her 680 feet of length,—being thus supported; while 150 feet at one end, and 180 feet at the other, were entirely unborne;—and the measured deflexion of the mass thus put to proof was only one half-inch from its true lines of Form. With a measurement capacity at 32-feet draft of water, for 12,000 tons of coal, and 4,000 tons of cargo, what structure of wood could approach to such powers of burthen without being torn piecemeal, long before completion, by the weight of its own material and fastenings,—like an attempt to bolt together a structure of cream-cheese? May I here confess my own unblenching faith, that if her present Managers and Proprietary,—of whom I am one,—do but fulfil their fitting charge of mere preservation, until relieved by abler men, or moved by truer counsels, the "Great Eastern" will yet accomplish her destined object of linking together our Home and our Indian Empires,—by a direct steam passage of under forty days; and that she will yet justify the sound judgment of both her great Designer, and her eminent Builder,

in their common decision, that such a conquest,—if achieved at all,—could never be permanently maintained by any vessel of "smaller" size.

So far back as 1845, all the advantages I have enumerated had been fully established, and in that year it was determined to endeavour to import them, on a fuller scale, from the Mercantile into the Royal Navy. Seventeen vessels belonging to Government, and either at work or building since 1839,—had furnished to the Authorities then in power a corroborative experience of their own. But these vessels, with one exception, were all either packets, tenders, or small river boats, lightly armed, for limited service only; and the occasion now taken advantage of, was the urgent demand to increase our real War-force,—especially in Steam,—in consequence of the differences with our powerful neighbour arising out of the well-known "Pritchard affair." Ever since 1839, the East India Company had employed iron for vessels of war; and the war-services of the "Nemesis" in China, and of the "Guadaloupe" in Mexico, had attracted great attention, and had been communicated to the Admiralty in all details, by the two British officers who respectively commanded them; and who were found to give common evidence,—obtained on two very separate spheres of action,—that no apprehension need be entertained, that the effects of shot, on ships of iron, were likely to compromise the safety of their more general introduction, or to present difficulties which might not readily be overcome. It is however, distinctly in evidence, that it was never intended by the then existing Authorities to go beyond the construction of the five Frigates at this time ordered,—until they should themselves have afforded sufficient experience to justify doing so. One of these, the "Birkenhead," of 1,400 tons, had been commenced since the winter of 1843, and was fitted with paddles; while the "Simoom," "Vulcan," "Greenock," and "Megæra," of from 2,000 to 1,400 tons each, were to be fitted with the Screw.

Whatever after-experience might be furnished from the War-services of these vessels, there is clear evidence, that not the least expectation was ever entertained that an enemy's shot would show more respect for a ship of iron, than it had ever done for a ship of wood, or that anything than the common risk to life and limb would attend all those who might be engaged in ships of either material; but the proposed Introduction seems to have been based on a general view of the balance of public advantages to be gained; and a hope of making that balance as large as should be found practicable, by the remedy of any difficulties as they might arise.

There was, however, one important motive of special force; the urgency of which, instead of passing away, has steadily increased from that time to the present. The pressure for appropriate timber for our ships was even then very serious; and no less than five different species,—from as many different parts of the globe, might be counted,—as I had myself often done at Portsmouth,—in the "beaming" alone of our ships then building, viz.: The oaks of England and Dalmatia with their acid;—the teak of India with its oil; the Norway pine and Polish larch with their resin; with the mahogany of America as a neutral; while elm, and ash, for outside purposes, were added to this motley list. The "discussion" on the great "Gun-boat question" has aptly illustrated this same pressure, at a

more proximate date. More recently still, its effects have yet to be realized in the fact, that the necessary alteration of all sterns, while converting our Sailing-ships into a Screw-fleet, for the past two years, has had to be made, for the greater part, by employing unseasoned timber precisely where it would best have been avoided. And the latest-known "view of the case" which has been brought to my notice was that of certain Professional Gentlemen with measuring tapes, said to be searching the depths of the New Forest for appropriate trees still standing, from which to frame some of the most important repairs now required by the "Royal Albert" at Plymouth. Now it is clearly stated that a primary object in the proposed use of iron was that of eventually constructing our Fleets out of a material of home supply, instead of one of foreign growth; and, in case of any sudden demand for an increase to the Fleet, that it might be met at once by the common effort of numerous establishments, employing a material at once abundant everywhere, of the best quality, and involving no subsequent risk of consequences from not being "properly seasoned."

As far back as 1842, a certain "shot experiment" had been made at Portsmouth, to verify results said to have been obtained in America; and I, therefore, only notice it here at all, in order to observe, that it was not connected with, and did not furnish results bearing on, the construction of the iron frigates. It consisted of firing 8-inch and 32-pounder shot, with full charges, from a distance of 400 yards, at a mass of 14 iron plates, 5 feet by 3, and 6 inches thick in all, secured together by 20 rivets, and fastened by 8 bolts to a section 14 feet by 7, and 2 feet thick, representing the scantling of an 80-gun ship at the lower deck. But of 8 shots which struck the plates, none seem to have actually passed through them and the timber, though two struck on the same spot; but both timber and plates were greatly shattered by the twenty-two shot in all which struck the target, the plating on which, besides its slight connection together, possessed so limited an "inertia" in its mass, as barely to prevent its own action, as a shot when struck with heavy impact.

An interval of some months elapsed, however, between ordering the frigates, and their commencement, and during that period experiments were instituted at Woolwich, with the direct object of eliciting any circumstances of value, which the actual experience of such vessels as had then been under fire, might not have brought to light; and these experiments were carried on from time to time, nearly into the summer of 1846. They were made by heavy 32-pounder guns at various distances, from 200 yards and under, with various charges,—against plates more or less similar in quality,—but always similar in thickness,—to those of some one of the vessels about to be built. Various thicknesses of oak and fir timber were also used in combination with the plates, and in one instance a composition of cork and india-rubber was used in combination with them. The effects of the shot were ascertained in the case of all these compound targets, by firing at the plates when in front of the backing, and at the backing when in front of the plates. In one case two similar targets were placed with the same space between them as the breadth of one of the vessels, and thus made to represent her two sides, so as to observe any difference which might occur between the

effects of the shot in passing in at the one side, and passing out at the other. And the effect of "spent shot" was also shown by bringing the muzzle of the gun close to the plates, and using a very low charge of powder. The most remarkable of the results thus obtained were, first, the entirely local effect of the shot when striking the plate, out of which a circular disc was struck, or taken, limited to the actual size of the shot,—and leaving the surrounding parts entirely unaffected by the operation. This effect was modified where the shot on passing out struck the plate on the reverse side, and near to a frame or angle iron, in which case the attachment of the plate to the angle iron was partially disturbed, sometimes for a distance of from two to three feet; and in some of these cases rivet-heads were driven off. A similarly modified effect was also observed when the backing of a plate in the compound targets was first struck, the effect in this case being extended over a larger surface than where there was no backing, or where the plate, instead of the backing, was first struck, with the disc, however, still cut out in all cases. And in the case of the "spent shot," although the usual clean hole of the same size as the shot was still made, the substance, instead of being altogether carried away, was simply turned inwards, and presented so many jagged and projecting points. When the discs were struck clean out by the shot of higher velocity, they appeared to assume a new nature from that of the tough plate of which they had formed a part, and, by their splinters, appeared to have become quite brittle. These splinters were considered to be very severe, it being chiefly with the view to intercept them that the timber was used in combination, and in some cases this had to be done to a thickness of 12 inches before any considerable interception was produced. To this splintering of the disc was also added *that of the shot itself* in many cases; and on one occasion a sentry on his post was struck by a splinter at a distance of from 200 to 300 yards from the target, and obliquely in front of it, the piece taken out of his leg being a fragment of a shot. Some oblique firing also appears to have taken place, producing the same clear round hole when the plate was struck between the angle-irons, but a hole of oval or oblong form when struck upon a frame or angle-iron. This "breaking up" of solid shot by plates of thin wrought iron was also one of the most remarkable results elicited; but it does not seem to have attracted on this occasion that attention which was afterwards given to it, when it was made to be, and still remains—without, however, any attempt as yet to remove or modify it,—the basis upon which "Ships of iron" are condemned as unfit for the "Purposes of war." The probability is, that, as the firing took place against the earthern butt, many of the broken-up shot passed into it without their shattered state being perceived, whereas, subsequently, when the target was afloat, the strike of every fragment upon the water was apparent. There can be no doubt, however, that whenever, during these experiments, the thickness of the plates amounted to $\frac{5}{8}$ of an inch, the shot were shivered to fragments, and that the anomaly was here first disclosed, of a material so soft and slight that it could be easily perforated, and yet possessing a property of resistance so strong, as to break in pieces its solid perforator;—an anomaly which, had it been fully perceived and brought to the notice of the Authority by whom these experiments were instituted, would certainly never have been left by him

to become a weapon in other hands wherewith to overthrow the great measure he was initiating, but would assuredly have been wrought out, step by step, to its inevitable conclusion,—of ascertaining the thickness of plate required,—not for breaking the shot into smaller and smaller fragments, but for stopping it altogether; and, instead of the doubt and perplexity of the present day, we should now have been resting in the security afforded by fifteen years' experience in the defensive power to be furnished out of our great supplies of iron. So much for the effects of former imperfect experiments.

These experiments produced, as was natural, different effects on different minds; but I find only one instance, among those more directly concerned, whose faith was shaken by them, and that faith seems to have been subsequently restored by direct reference to the experience of the "Nemesis" and "Guadaloupe,"—as having fully justified the intended adoption of iron into the Fleet. Upon the mind of the one Professional Authority chiefly responsible, both for proposing and carrying out that adoption, the general effect of these experiments was of a nature altogether confirmatory, some of the results being considered by him "highly satisfactory," and none being held by him to warrant any surrender of a reasonable confidence in the ultimate issue. It was seen that the experiments themselves were only one-sided, and afforded no means for balancing the relative effects between wood and iron, under equal circumstances. They were made on mere fragmentary representations of the vessels themselves, and could only in degree present their real conditions of resistance; while, very properly, the full power of unopposed attack was deliberately employed against them under every circumstance of advantage. Cold shot also alone was used; although at that day far more destructive missiles were in full use, and the comparative effects of these on structures of wood, and of iron, might be found to differ very widely, and by no means necessarily so, to the disadvantage of iron. It was shown that unlucky shot-holes between wind and water, if occurring on the fighting side, were very easily plugged; and that even the most irregular rending of a plate which could be contemplated, could scarcely exceed the powers of security which had been well proved to exist,—at least against a fatal result,—in a well-devised system of bulkheads,—which neither then, nor since, had ever been studied with the express view of obviating the effects of shot. Means and appliances for preventing, or reducing, the amount of splinters, were far from being exhausted; and, even if they had been, there were no grounds on which to conclude that, under a common fire of all missiles even then in use, they would prove to be either more numerous or severe than those produced from a fabric of wood. So the building of the four new iron frigates for the Screw was proceeded with; and the very fact of the extent and continuance of these Woolwich experiments must be held, I think, to refute any charge that this proceeding was determined on with either reckless or inconsiderate haste.

We have now arrived at the summer of 1846, and, as the experiments just described alone furnished,—up to this time,—such details as either were or could be advanced against the fitness of iron for ships of war, it seems a fair period of my history in which to sum up, equally in detail, whatever facts of a favourable nature had then been supplied, by such vessels of that material as had actually stood proof before the fire of an enemy. The

number thus engaged had been four:—the "Nemesis," of near 700 tons, built of $\frac{3}{8}$ths plates, during a service of three years in China; the "Guadaloupe," of 800 tons, and $\frac{3}{8}$ and $\frac{1}{2}$ inch plates, during a service of two years on the coast of Mexico; and the "Lizard," and "Harpy," both of 340 tons, and of $\frac{3}{8}$ plates, during their services in the Parana. The size and scantling of all these vessels, be it observed, being considerably less than that of the new frigates, and thus showing a difference in favour of these latter of a very practical nature;—since any given amount of firing, whether against ships of wood or of iron, must be less severely felt by the larger than by the smaller vessel.

For these details I quote the two following letters from the respective captains of the two first-named vessels, and which were publicly read in the House of Commons, in the beginning of the following year.

Captain Hall, R.N., writes:

"Nemesis" was frequently struck, as often as fourteen times in one action, and much damaged by shot in her upper works. But only one shot can be said to have gone straight through the vessel, which made a hole as if you had put your finger through a piece of brown paper. Other shot struck the "Nemesis" in a slanting direction, and merely indented the iron, glancing off without penetrating. We remarked no particular danger from splinters of iron; but I would remark, that the "Nemesis" was constructed of the best possible material, and put together with the best possible workmanship. She was divided into seven water-tight compartments; and I am of decided opinion that no war steamer of iron should be divided into less. The "Nemesis" had holes knocked in her bottom many times by sharp rocks, and these were easily stopped for the time, by driving in plugs of wood and oakum from the inside. For myself, judging from my own experince, and well knowing that the sides of iron steamers (particularly between wind and water) could be strengthened and supported, so as to prevent the destructive effects of shot, which have caused so much alarm, I should still give the preference to an iron over a wooden steamer, as a command, under all circumstances.

Captain Charlewood, R.N., writes:

Notwithstanding all the extraordinary reports which have been sent home of the effects of shot upon one of our iron men-of-war, my opinion is as strong as ever upon this point, providing the vessel is properly built. And I should still certainly prefer commanding an iron steam frigate to a wooden one. I think, also, that you will consider my opinion as to the effects of shot upon iron vessels as not a rash one, or made upon slight grounds, when I inform you of the following particular cases which occurred to the "Guadaloupe" Mexican frigate, two of which occurred when I was actually on board in command of the vessel, and the others very shortly after the Admiralty orders reached me instructing me to return home, when Mr. Martin, a relative of mine, was in command. Full particulars of each case I have both from him and other officers who were on board.

No. 1. A 24-pound shot struck the vessel on the bow where the woodwork of the head is bolted to the bow, and consequently lies over the iron side. This shot, fired from a distance of about 1,000 yards, passed through the woodwork (say about five inches thick) and iron, and dropped on board, simply making a hole sufficiently large to let the shot pass through.

No. 2. A shot struck the counter, indented the iron, and glanced off; had the vessel been constructed of wood, this shot, I think, would have entered.

No. 3. A 24-pound shot nearly spent struck the iron bulwark on the inside, having passed over the port side of the vessel. This shot started the iron, and burst the rivets of a plate for about nine inches in length.

No. 4. A full plumper 24-pound shot struck just abaft the mainmast on the port side, and about two feet under water; this shot passed through the side and lodged in the coal bunker; the hole was made quite tight temporarily with a common plug; no rivets were started, or damage done beyond the circular hole made by the shot.

No. 5. An 18lb. shot fired at a distance of about 200 yards. This shot struck the vessel's side near the foremast, passed through the iron, making a clean hole as if it had been drilled, and through three casks of salt provisions.

These shot-holes were all repaired by the boiler-makers, who served on board as engineers and firemen. Four holes were drilled round each shot-hole, from the inside, corresponding with four holes in an iron plate lowered down outside, and four screw bolts made them perfectly tight and secure, not a drop of water finding its way through. The vessel was in severe weather repeatedly afterwards, and I believe to this day nothing more has been done to these shot-holes. I should remark, that the case of No. 3, of the spent shot, would have been the worst leak to contend with had it struck the vessel under water, as a plug could not easily have been applied; but still the leak would not have been, comparatively, a severe one. Several other shots struck the vessel about the hull when I was on board, and afterwards; but these are the only cases worth mentioning, and which have any bearing on the question in point.

Lieutenant Proctor, R.N. commanding the "Harpy," writes:

One shot only, after passing through two floats and damaging a segment of the wheel, struck the iron portion of the hull immediately outside an angle iron. The shot had not sufficient momentum to pass through the side, but caused a split in the form of a cross, breaking the said angle iron, which there is no doubt impeded the shot from passing through. It was necessary to rivet a patch of sheet-iron, a foot square, over the part damaged.

Lieutenant Tylden, R.N. commanding the "Lizard," writes:

This vessel received seven shots between wind and water, besides nine cannon, fourteen grape, and forty-one musket balls in the hull and bulwarks, and seven cannon and grape shot in the funnel and steam-pipe.

And writing of when his own guns would no longer bear, he goes on:

At the same time, the heavy shot, grape, and musketry, riddling the vessel from stem to stern, I ordered the officers and men to go below; but the step, I regret to say, had not the desired effect, two officers being killed in the gun-room.

The circumstances referred to in the two latter cases took place respectively on the 6th and 21st of April, 1846, when the "Harpy" and "Lizard" were separately making their way up the Parana, and had to encounter the batteries erected to obstruct them, on the cliffs at the point of San Lorenzo. The "Harpy" seems to have succeeded better than her sister, in getting under the cliffs, and inside the angle of greatest depression of the enemy's guns; but both vessels had to sustain, for near an hour, a heavy fire from large guns, field-pieces, and a large body of infantry, at a minimum distance of sixty yards; with great damage to upper works, masts, and rigging, in both cases, besides the further damage just detailed in the case of the "Lizard." Only one casualty occurred in the "Harpy," the commander himself being wounded by a cannon shot; but the "Lizard" had four killed and four wounded. I find both these vessels, in thorough repair, sharing in the encounter with these same batteries on their passing down the river again on the 4th of June following; and both are still sound and well on the active list of the Navy.

On the 27th of the following July, the commander of the "Lizard" writes a further letter, forwarding therewith to the Admiralty a grape shot, in evidence of the liability of his vessel to penetration, and which shot he describes as—

One of the smallest of those which, when passing the batteries of San Lorenzo on the 21st of April, 1846, struck this vessel forward, about a foot from the water-line, penetrating the iron side; carrying the accompanying portion of it through the lining and two bulkheads, and lodging in the side of the vessel.

And shortly after the arrival of this shot in England, a letter was received from a person at Liverpool, requesting the Admiralty that it might be given to him, on the ground of his having seen a "report" in

the "Times," which stated that it had killed his brother; and it was accordingly sent to him; but not a word of allusion to any such circumstance is to be found in the letter itself of Lieutenant Tylden, who, when describing so minutely the several obstacles which the shot had encountered, was not likely to have omitted all reference to the fact of its having likewise caused death,—if a fact it had been.

It was the sending home of this shot, however, which suggested the order for the "Harpy" also to report whatever effects had been produced on her hull by the enemy's fire, and which report I have already quoted. But the sending home to England such an object at all, bears strong evidence of the then prevalent and serious error,—that sides of iron, however thin, were expected and intended to act as a charm, or specific against shot.

It is believed that, through the courteous permission of their Lordships, these official details concerning the "Harpy" and "Lizard" are now for the first time made public; and the necessity for doing so thus minutely must be laid to the charge of the following sentence which occurs in the 172nd article of the 2nd part of Sir Howard Douglas's "Naval Gunnery," 5th edition:

> In consequence of the ship ("Lizard") being struck, the splinters and rivets detached by the shot flew about like grape, and nearly all the men killed and wounded suffered from this cause.

Now there may, no doubt, exist records or descriptions,—somewhere,—which go to support this very succinct statement; but I can safely say that none of those at present known in the Admiralty can be made to do so, to any greater extent than is involved in the portions of them which I have quoted; and that, neither in the dispatches themselves, nor in any notes to the "List of killed and wounded," have I succeeded in detecting a word to justify the conclusion that any one of the casualties was attributable, or attributed, to the peculiar material of the vessel. Neither is it so alleged by the most hostile parties, when debating this subject in the House of Commons. On the other hand, I take no objection against that portion of Sir Howard's information, whencesoever derived, where he so ably describes, in the very same article, the simple and ingenious device by which the "Lizard" so effectually plugged her numerous shot-holes. It is christened by Sir Howard a "parasol plug," and

> Consisted of an iron bolt furnished with arms of the same metal, and covered with thick canvas well tarred. On being thrust through the shot-holes and forcibly drawn back, the head expanded, and thus, the aperture being covered, the leak was closed.

A description which I have quoted in hopes it may "yet" prove to be valuable, like so much of the contents of the volume I take it from.

But I must again request to notice the serious discrepancies which exist in the two accounts of Sir Howard and myself in respect to the experiments at Woolwich;—as regards the date of their occurrence,—by whom they were ordered,—and the effect they produced; and I may here say, once for all, that in tracing out my present history, whenever it shall be my misfortune to differ from Sir Howard Douglas, it will always be with the truest and most respectful regret. We have but one Sir Howard Douglas, and in the labours he has undertaken for us,

and in the clearness and power with which they are stated,—for the instruction of the youngest amongst us,—no man who may fairly differ from his conclusions, may presume to pass such difference by unnoticed, with any just regard either to the subject he treats of,—to the high character and talents of his opponent,—or to himself. In our respective views of the relative merits of wood and iron for ships of war, I differ from Sir Howard as perfectly as black does from white, and it is out of his own armoury I intend to take the choicest weapons wherewith to establish my point against his: but if presumptuously I should succeed, in however small a degree, in effecting the good I aim at, I am well assured that none more than Sir Howard will sincerely rejoice, although public benefit should be elicited in a direction the very reverse of that in which he himself has so long, and honourably, and earnestly laboured for it.

I will now read, with permission, the equally succinct statement as before, contained in the fifth page of the recent "Postscript to the Section on Iron Defences," in which Sir Howard says:—

> Soon after my return from the Ionian Islands, in 1841, I was consulted by the late Sir Robert Peel, on his accession to the Government, as to the use and efficiency of a certain half-dozen iron frigates, two of which were finished, and four constructing by contract: I stated in reply, that vessels wholly constructed of iron were utterly unfit for all the purposes of war, whether armed, or as transports for the conveyance of troops. I stated that a shot striking with great velocity would drive into the ship numerous splinters of the disc struck; that shot striking with reduced velocity, as when fired from a distance, would make large jagged holes which could not be plugged from the inside; that shot striking a rivet or rivets, as at the junction of four plates they might do, would make a large breach in the side of the ship; that the shot might break on impact, and its fragments, together with those of the plates, would drive into the ship a mass of splinters, consisting of pieces of shot, bolts, bolt-heads, nuts, and innumerable pieces of iron, which would prove far more deadly and extensive than any shell, grape shot, or case shot. Experiments were thereupon ordered, to test the efficiency of these ships, by erecting a target, a fac-simile of a portion of such vessels at Woolwich. I attended the experiments. After the firing ceased, I picked up in the target (which consisted of both sides of a ship, a deck, and ceiling,) a bagful of fragments of iron, pieces of shot, and very numerous small splinters of the plates, and found abundant proof how forcibly they had been driven against the further side of the target. These experiments put an end to the construction of iron vessels at that time.

By the cross bearings of both a public and a private event, the date of this consultation by Sir Robert Peel is unmistakeably fixed for 1841; yet, if indeed it concerned any iron frigate whatever, actually built at the time of its occurrence, then it could not have taken place before December, 1845, when, and not before, the first of the said frigates, the "Birkenhead," was "finished;" neither was any second one "finished" before January, 1849, more than two years after Sir Robert left office. Moreover, as the "Birkenhead" took twenty months to build, she must, in order to have been "finished" in 1841 at all, have been commenced no later than May, 1840; at which time the "Dover," mail packet, was the only iron vessel possessed by the Government, nor was a second vessel of this material even so much as "ordered" before the August of that year, as may be seen by any one who will consult any of the "returns" about "iron vessels," which were at one time so rife, and are still so accessible. So that there is much mist, if not mystery, surrounding both the date and the subject of this "consultation." Again, I cannot question,—I can only

admire,—the remarkable prescience displayed in the details stated to the Prime Minister in reply. Having been myself a student at Woolwich in 1846, when the experiments I have described were barely finished, I well remember the surprise excited by the anomalies then first discovered, viz., that the impact of a shot could change the nature of tough iron into a resemblance to that of brittle glass; and that, though a shot would penetrate a $\frac{5}{8}$ plate with the greatest ease, yet the effort required for doing so was such as to break it to pieces. And this "prescience," which could disclose these and other details so long before they were more generally made known, will no doubt account for what might otherwise be charged as a large departure from the presumed impartiality of a judge upon his judgment-seat, viz., that he should first pronounce an unqualified condemnation on a subject yet under "consultation," and then suggest that experiments be "ordered" to test the correctness of his decision. And when I further find that the letters I have quoted of the experience afforded by the "Nemesis" and "Guadaloupe" were publicly read in the Assembly of which Sir Howard was then a Member, and of which letters he therefore might have been a hearer,—and yet that no allusion is made even to the existence of these vessels, so far as I can detect, either in his chief work or its recent "Postscript,"—I can only conclude, as I trust without injustice, that Sir Howard's mind must have been made up so early and so inflexibly on the whole subject, as to lead to the "decision" that it was not worth the trouble of any impartial examination whatever. But, in justice to others, I must remove the erroneous impression conveyed in the paragraph under review, that Sir Howard was indeed the occasion of the Woolwich experiments,—not a trace of which can I discover in any other piece of printing than his own; but, on the contrary, the evidence is distinct, that they were initiated by the Chief Naval Authority so deeply concerned in the results they might disclose, as is also confirmed by the fact that, though the Arsenal authorities performed the actual firing, the targets fired at were the design and material of the Dockyard. Neither can I allow that "these experiments," as stated, "put an end to the construction of iron vessels at that time;"—and for this reason, that it was precisely "at that time" that it was determined to "commence building" the four frigates, which till then were only "ordered," as well as to prosecute the "building" of the fifth one to completion;—the confirmation to do so, in both cases, resting on the results of these very experiments. Neither, throughout all the discussions or examinations which subsequently took place on this *vexata questio*, is there a trace of these results being used, even by the most adverse party, as condemnatory of the building of the iron frigates,—except in the very limited and temporary case I have before quoted;—and of course in that very full and permanent case I am now dealing with,—in which the Author shows us how he used the results of these experiments for purposes of the most undoubted condemnation, both several years before the experiments which produced them were made; and how he still continues to use them for the same purpose, so many years after they were finished.

May I here transgress my own rule with a single exception, to pay a passing tribute of honour and respect to the memory of the Naval Chief by whom this proposed substitution of iron for wood as the material for our "Fleet of the Future" was first initiated, and always maintained,—the

late Right Honourable Sir George Cockburn,—the first to win for the Navy the dignity of a Privy Councillor; and one of the last who died as "Admiral of the Fleet." Approved by the unerring test of the "Long war," as one of the ablest Seamen it produced, his powerful and sagacious mind enabled him to triumph over the professional prejudices of a life, and fully to appreciate, and ardently promote, the all-important part which Steam-power was destined to enact in the future decisions of naval warfare. To his happy instinct in seizing the right moment, we are indebted for our present "Screw Fleet," the solid foundation for which was laid by him in the large addition to our Steam force, required by the political circumstances of 1845, when twenty-three Screw-ships of different sizes and classes, and engines of near 10,000 horse power, on several different plans, but all protected like the Propeller itself by working under water, were at once ordered; and out of the seed thus broadly sown he thereby lived to see the fruit of a confirmed System, which, though still in its youth, gives ample promise of its ability to meet every demand which the laws of future Progress may make on it. And the necessary complement to this great change, by the employment of a material which could alone produce Fabrics able to bear the stress of that huge effort which high speed upon the ocean demands, was the work and object of the same ample intelligence. And, although on its introduction the use of iron was first misunderstood,—then misrepresented,—then perverted into a weapon of strife in a warfare it had no concern with,—and lastly made even a term of reproach: yet "wisdom is justified of her children;" and that which was scornfully rejected in the form of a steady progress, when proposed by one of ourselves, the Stranger now forces on our reluctance with the force of an undeniable revolution, vindicating the posthumous fame of the one great-minded man, to whose clear professional foresight the "future Screw-Fleet of iron," like the "present Screw-Fleet of wood,"—will alike be due.

I now with confidence appeal to the judgment of all who have accompanied me thus far, that no practical evidence can be adduced either from the experiments made at home, or from the actual experience obtained from abroad, tending to establish any intrinsic property in iron, which should disqualify its use for Ships-of-war, or place it in an inferior position, in this respect, to wood,—and this quite irrespective of the obvious inferiority of the latter material to withstand the effects of red-hot shot.

In the summer of 1846 an entire change took place in the Naval Administration of the Country. The introduction into the Navy of the Screw-propeller, together with its complement "introduction" of the use of iron, were both at that time in a state of incompleteness. The new Naval Government decided against the plans found in the office. Circulars were at once sent round to every Engineer engaged on the screw-engines inquiring if the works could be stopped; and the common reply that they could not, and if they could that no other customers could possibly be found for them,—neither could they be made to work paddle-wheels,—alone saved the present "Screw fleet" from perishing. The engines, and the ships prepared for them, had perforce to be put together, and the merits of the Screw itself did the rest. But the ships of iron,—they could resort to no such special defences. They might be sold even

unfinished as they were;—or they might be finished, and then degraded to a less dignified use than that of "ships of war," for which they were designed. It was decided to submit the Iron-ships to a severe trial, but the instrument selected for that purpose was by no means calculated to give confidence in that trial.

In 1841 a small iron steamer, of 73 tons, 20-horse-power engines, and a coal-stowage of 2 tons, had been built at Bristol, of the very slight material of one-eighth plates; and in her employment of taking ship-wrights to and fro between Portsmouth Harbour and Spithead, she had been already worn out and formally condemned as unsafe. This was to be the representative,—and this is the description of her state as recorded in the evidence of the Officers who surveyed her:—

> Her state was very bad: the iron of which she was constructed was originally very thin —not thicker than a half-crown; the seams of the rivets were many of them almost quite gone; the ribs were very far apart—I should consider it likely they were about four feet apart, instead of being perhaps ten inches or a foot; the heads of her rivets were quite gone, especially internally; the deck was also partly removed for the purpose of lifting the machinery out previous to the experiment, and made the vessel still weaker.

And, by another of her surveying Officers, it is stated that the plating between the ribs yielded so much to the foot as to lead to the conclusion that it could not safely bear a man's weight.

In this state the "Ruby" was placed before the broadside of the gunnery three-decker at Portsmouth;—for the purpose of proving what would be the effects of shot on the sides of the new iron ships, the thinnest portion of which was of half-inch plates, and varied from that to three-quarters of an inch in thickness. She afforded practice for two days; 40 shots in all being fired through her from a distance of 450 yards, with all guns, and all charges, from the 10-inch Paixhans to the 32-pounder carronade, and in all cases with complete success;—the vessel being swung round during the operation, so as to receive her full share of punishment, "end on" as well as "broadside on,"—all effects, of each shot, being minutely described, and measured, and pictured, and duly reported. But throughout this very minute "report," and throughout every subsequent reference made to it, it is remarkable to observe how every word which could inform us of the original thickness of the "Ruby's" plates, or their actual state when fired at, seems to have been overlooked; not that this "report" itself, with its illustrative pictures, was at all procurable at the time, nor did it indeed become so, until it took position as "Parliamentary Return No. 737, of 1850," at which time the "Ruby" flag was worn out, and hauled down, by the same hands which had hoisted it, and so long and manfully fought under it,—the condemnation of iron being thenceforth based on more substantial experiments. This "Return," however, now affords us undeniable data for determining the capability of the "Ruby" as a true representative of the iron ships, as it contains a scale, fixed from experiments made by the "Excellent" herself, of the relative powers of resistance of wood and iron in certain graduated proportions, beginning with a fire of musketry, and rising up to that of grape-shot, by which it is proved, that a three-eighths thickness of iron plate is necessary to resist penetration,—not by a shot of iron, but by a bullet of lead;—so that pistol practice, or, at the utmost, distant musket practice,—not that of 10-inch guns, with 12lb. charges,—was the only true or rational use to

which the "Ruby," as a target, could have been put at all,—*even if her plates had been sound*;—in which state their power of resistance would have been equivalent, as the scale shows, to no more than that of a 1-inch oak plank.

On the event itself I make these remarks:—

1. Not a word of reference to it is to be found throughout the pages of Sir Howard Douglas, which I accept as strong proof of his entire condemnation of the so-called "experiment."

2. No such experiment could have been made at all in presence of more than one set of views or opinions; it could not,—it durst not,—have been even proposed.

3. Its occurrence at all bears strong witness that nothing could be found in the Woolwich experiments,—then scarcely closed,—by which to support the intended condemnation.

4. It shows plainly how the best labours for the introduction of improvements, undertaken by the ablest experience, and supported by ample practical proof, may be at once overthrown.

5. I deny that this experiment could have originated in any "Professional" requirements or doubts; no event had occurred since the Woolwich experiments to excite the one or the other; and, if excited, it could have ministered no rational relief to either.

6. The mutilated remains were sold for 20*l.*

It was the 7th of August when the life of the "Ruby" was thus violently closed; but it was also within three weeks of the annual closing of those "Lists," where the results of this "life-taking" were to be fought out, and there was no time therefore for much active use of the weapon which had thus been secured; but an ominous intimation was given that the result of the "*only experiment yet made to try the effect of shot on ships of iron*" was such as to call for great caution, and cause grave doubt,—whether the construction of the ships then building ought to be persevered in. In vain were the letters of Captains Hall and Charlewood read in evidence against the "Ruby;" and in vain the reference to the Woolwich experiments, as having preceded the actual building of the frigates,—the only vessels out of the whole number ever intended for actual war. The resolution was soon made known that the ships were to be,—not sold,—but finished; that their Steam-power, with exception of that of the "Birkenhead," was to be reduced by about one-half, and that the ships should then be fitted and used,—not as men-of-war,—as originally intended, but as Transports;—all of which was accordingly acted upon, without either attempt or intention that, even when finished, the vessels themselves should be put to any proof whatsoever. And so it came to pass. In a question purely Naval, and in direct violation of all Naval experience,—judgment was pronounced against five new iron frigates, having a mean burthen of 1,600 tons, as being totally unfit to undergo the same ordeal of War-service as the four iron gun-vessels, with a mean burthen of only 550 tons, were then known by that same Authority to have actually undergone, in three different parts of the globe, with complete success.

So much for what has been, and may be, accomplished by the power of "exclusive experiments."

Monday, March 18th, 1861.

Captain E. G. FISHBOURNE, R.N. C.B. in the Chair.

IRON-CASED SHIPS—*continued.*

"Simoom" Experiments of 1849, 1850, 1851—Spherical Shot and Shell.

By Captain E. PELLEW HALSTED, R N.

In the searching examinations which took place before the Estimates Committee of 1848, much evidence and many opinions were elicited on the moot subject of iron and wood. The experience of the Captains of the "Nemesis" and "Guadaloupe" were there given in several important details with great minuteness, and there the state of the "Ruby" when fired at, was divulged. Several valuable and favourable views of the prospects and properties of iron were also put forth by other able and experienced parties, the relative weight of whose opinions may be easily examined by aid of the admirable Index to the voluminous Report of the Committee. Of course, all favourable views were elicited by the examinations of the late tenants of political Power, while the then holders of it seem to have met this mode of warfare by steadfast allegiance to the results of the "Ruby," generally referred to under the term of "The Portsmouth experiments."

In 1849, however, are to be traced the circumstances which led to the next open revival of the struggle, and produced those further and more rational experiments which furnished the condemnation of the use of iron for ships of war as it stands to the present day.

In every Mail contract the vessels to be employed are required to be so constructed as may enable them in time of emergency to be taken for the public Service; and as several of the Steam Companies holding these contracts, and especially the one which still ranks as the giant of the race, had largely adopted the use of iron, and all were steadily increasing the number of such vessels, it seems to have occurred to the anti-iron champions that the victory so gallantly won in front, might be compromised or even lost by this liability to attack by a flank movement, to prevent all chance of which it was resolved to carry the war beyond the sphere of the Fleet Royal and expurgate the foe from its position in that of the Merchant. Accordingly a Committee was appointed under competent authority, which duly came to the unanimous verdict that the terms of the contracts had not been observed by the Mail Companies in respect to the adaptation of their vessels of iron for the

purposes of war; and this verdict was brought into direct application by means of a further Select Committee, appointed by the Legislature in the beginning of the above-named year. The subject thus specially submitted for inquiry was the desirableness of fitting the entire merchant Steam Fleet so as to enable it to be employed as auxiliary to the Navy in protecting the home coasts in case of hostilities; in remuneration for the maintenance of which fitments, certain privileges or payments were to be assigned in respect to each vessel fitted, and the exclusion from these privileges of all vessels of iron was felt to be little less than a tax against the use of that material, and pressed all the more sorely on both the builders and owners of such vessels, as proof of the many advantages they possessed over those of wood was just at that time becoming daily manifest, especially in regard to strength of structure where a constant high postal speed had been contracted for. It was before this Committee that an acknowledgement was forced that the "Ruby" had indeed been a "vessel very slightly built;" and, notwithstanding the sentence which had been passed against iron,—"That no vessel of that material intended for real war had yet been subjected by experiment to any proof of shot whatever;" —the very argument used against the introducers of iron at the time of its condemnation, and which, if not practically refuted, seemed likely to be employed as a formidable weapon against those who had produced it. Thus seems to have originated the next, and the last, extensive series of shot experiments against the material for ships of iron, which began in November, 1849, and lasted on, with intervals, till August, 1851. The first portions are given, with results and illustrations, in the Blue Book No. 737 of 1850, and the entire series, with one most weighty, and perhaps involuntary, omission, in the second part of Sir Howard Douglas's fifth edition of Naval Gunnery. I shall quote indifferently from both these authorities, according as I find them to support my own views, and of course shall thereby open my statements to fair challenge by any who may think those views to be controverted, rather than supported, by the works referred to.

The experiments ordered in November, 1849, were limited to ascertaining those relative powers of resistance of oak plank and iron plating which I before had occasion to use when telling the tale of the "Ruby;" but I did not then state, that they go to establish a very remarkable coincidence, if it be not a direct relation, between the powers of resistance to the impact of shot, and the proportional specific gravities (1 to 8) of the two materials. The experiments are also valuable from the regularity of their gradations, and it, therefore, is the more to be regretted that they are not complete. They establish that a $\frac{3}{8}$ plate and a 3-inch oak plank are both musket-proof at 40 yards; that a $\frac{4}{8}$, or a half-inch, plate and a 4-inch plank are both canister-proof at 100 yards with a 6lb. charge from the 32-pounder; and that a $\frac{6}{8}$, or three-quarter inch, plate and a 6-inch oak plank were neither of them proof against grape-shot from the same gun and with the same charge at 200 yards; but we are not told anything further; and it is this incompleteness, of not ascertaining the relative thickness of plate and of wood which *is* grape-shot proof, that I have ventured to regret. These experiments seem to have had in view a general, rather than a specific, object; but those which

followed, and commenced in June 1850, were specially intended to illustrate the effects of shot on the "Simoom," the largest of the quondam frigates, and which had then been launched since May, 1849, without, apparently, having suggested any earlier test of her shot and shell properties.

In Sir Howard's account of these experiments, I find the description of a great many sorts of sides, all represented as belonging to the "Simoom;" sides varying in material, in thickness, and in nature and mode of construction; sometimes they are of iron plating only, sometimes of iron and wood combined, now with the iron inside, and now with it out; now with iron plates over wooden timbers, and now with wooden plates over iron timbers. In short, many strange devices and structures were fired at, almost all of which are spoken of as "the sides," or similar to the sides, of the "Simoom;" and this makes it necessary for me to point out, that the two experiments described, and which are stated to have taken place respectively "in June, 1850" and "on the 11th of July, 1850," are those alone to which I shall attach any real importance, as these are also the only ones of which the details are given in the Blue Book; and of the targets used on these two occasions, that one used on the last of the above days is the only one out of the whole series which presented a true section of the side of the "Simoom," and for the effects on which, that ship, or any such, can be held responsible. I shall designate these two targets respectively as Nos. 1 and 2, and proceed to observe of them, that No. 1 was a double section, or a section of both the sides of the ship, but of the ironwork of those sides only, and without the wood-work. It was fired at from a range of 450 yards, as was also No. 2, with various guns and various charges, the rear section being placed 35 feet behind the front one; and immediately between the two, at a distance of 10 feet from the front section, was placed a screen of one-inch fir plank, together with a more extended screen of canvas, the one to prove the severity of the splinters, the other to show their number; the plates of both sections being of $\frac{5}{8}$ thickness, and built together, in all respects as regards iron work, in the same manner as in the vessel herself.

But in addition to this faithfulness of representation in No. 1 target, in respect to the iron portion, No. 2 target faithfully represented the true structure of the "Simoom's" sides in respect to wood also; and I think that the following description, as given in the Report, will show that this difference between the two was not unimportant, as the difference of the effects of the firing in the two cases did in reality prove. The Report states of No. 2 target:

> It was filled in and made solid with 5½-inch oak timber between the iron ribs, and 4-inch oak planking above the water ways, which were 1 foot thick, and 3-inch fir plank above the port-sills. These were strongly secured to the iron plates by bolts "through all," and clenched; *in fact, the inside timber was that of a frigate, with a casing outside of ⅝-inch iron plates.*

Rather a *naïve* statement, it will be admitted, when compared with the description in the Report of No. 1 target, by which it will be seen that this "inside timber of a frigate" had been purposely omitted, "because

it would not have added to the safety of a vessel or crew;" and this intentional omission becomes especially noticeable from the fact, that this timber support had been given to the ship when building, consequent upon the proof of its value as shown by the Woolwich experiments, and for the express purpose, among others, of intercepting splinters, which, as in the Woolwich cases, it will be shown that it was really found to do. It is much to be regretted however that No. 2 was not a double target, like No. 1; and that the use of screens was not resorted to in this case also in order to show the number and severity of splinters, as we should then have had valuable data whereby to assist in determining a very important point of the present day; viz., the practical difference shown, by a similar fire on similar plates, having in the one case a backing of timber, and having in the other none; any practical difference of the effects of *splintering* in these two cases being in truth the point of most value to be elicited from these experiments at all, since the question of *penetration* had been already determined by the experiments of November, when $\frac{5}{8}$ and even $\frac{6}{8}$ plates were shown to be perfectly penetrable by 32-pounder grape-shot with only a 6lb. charge at a distance of 200 yards.

I find that these "Simoom" experiments were again entirely one-sided; and, like the former ones at Woolwich, they furnished no data for determining comparative effects of an equal fire on equal targets of wood and iron—as, indeed, it is more than probable they were never intended to do. But, thanks to the armoury of Sir Howard, this important desideratum I shall, to a considerable extent, be enabled to supply, by resorting to that portion of his work in which he gives us in full detail the effects of a fire of solid and hollow shot, directed from the same gunnery ship in 1838, against the sides of the "Prince George" hulk, for the express purpose of deliberately examining such effects, and which I proceed to use for my purpose thus. I will extract from the details of the firing at No. 1 and No. 2 targets two cases each, such as appear to me to have produced the most destructive effects on the iron plates; and against these I will quote four cases of the most destructive effects on the sides of wood; but, as in the latter case no 10-inch shot were fired, I think it fair also to omit the effects of firing at the targets with this sized shot; hoping that the day is near when this, and many other practical points at length happily recognised as of true National importance, will be made the subject of fair, open, and comparative experiment.

No. 1 Target.

No. 1 shot, 32-lb. solid, charge 6 lb.—Struck the 2nd row of plates, making a hole 8 by 9¼ inches between the 5th and 6th ribs from the left of the target. The shot split, and there were a great many splinters, which spread very much. The wooden screen behind, and placed about 10 feet from the iron plates, had two planks knocked down, and about 25 splinters passed through it. In the rear target, part of No. 6 rib was knocked away, and a hole made by one of the splinters passing through the plate, 32 splinters struck the target, one broke the 2nd rib and knocked off two rivet heads.

No. 7, 8-inch hollow shot, charge 10 lbs.—Struck the 4th row of plates, making a hole 15 by 9 inches, and curling up the plate at the back, leaving a very ragged hole; the 5th rib was hit, and about 11 inches of it and the flange were very much broken; 4

rivets were knocked away. The shot split, there were a great many splinters, one of which struck about 80 yards, and nearly at right angles to the line of fire.

No. 2 Target.

No. 7 shot, 32 lbs. solid, charge 10lbs.—First graze 8 yards short, shot struck the section, making a round hole through the iron and wood 8¼ inches. The shot split into very many pieces; *the wood stopped the splinters of iron plate*, but not those of the shot, which ranged about 300 yards.

No. 9, 8-inch hollow shot, charge 10 lbs.—Struck the section on the left angle rib, shot split into a great number of pieces, which ranged on, covering a space of from 100 to 300 yards in length, and 60 in breadth, diameters of hole 10 inches by 9 inches.

Before putting before you the details of firing at wood, I think it fair to submit for your consideration that, as these were never made for that comparative purpose I am applying them to, it is more than probable that the amount of splinters of all sizes actually made were never counted or noted with the same accuracy and minuteness as was provided for in the case of the "Simoom" targets.

I proceed to quote from the 161st, 162nd, and 165th articles of Sir Howard Douglas's work, fifth edition, as follows, taking the shot detailed in the 161st article as two, out of the four, cases for comparison:—

161st Article.—Two 32-pounder shot fired separately, with charges of 10lbs. 11 ozs. entered at the same place, so as to render it impossible to distinguish their separate effects; together, after penetrating through the ship's side in firm wood, they shattered a sound wooden knee; they then passed across the deck, cutting down a wooden stanchion 6 feet long and 8 inches square; this they shattered to pieces, causing many splinters, six of which were very large, and one of them swept the deck as far as the pumps; one of the two shot penetrated its own depth in sound wood on the opposite side of the deck, and there stuck; the other struck and splintered a port on the opposite side, after which it rebounded against the side which it first entered.

162nd Article. Many hollow shot were fired with remarkable effects from 68-pounder guns, making penetrations which varied from 25 to 56 inches. One of these, with a charge of 8 lbs., penetrated the side of the hulk, passing through 28 inches of good wood, tore out the iron hook which holds the port-hinge, and fractured the after side of the port, driving the splinters about the deck. It rent away the end of a beam, grazed the deck, passing through two planks, and cutting down a stanchion 8 inches square, making several large splinters; it then struck against the opposite side of the ship, from whence it rebounded against that which it entered.

165th Article.—A 68-pounder shot, with a charge of 8 lbs. and an elevation of 1 degree, after two bounds penetrated to a depth of 24 inches, close to the side of a port just above the lower port-sill, in bad wood, started the inside planking, and tore off a piece, which splintered. One of the splinters, a very large one, was thrown beyond the main hatchway to the opposite side of the deck. The shot having crossed the deck struck a corner of the main hatchway combings, and tore out a large piece on each side, destroying the use of the combings. It struck a winch handle which was lying on the deck, and drove one end of it through a port-scuttle. After striking the combings the shot grazed a beam and fell on the deck.

Among the assembly I have the honour to address there are many far more competent than myself to weigh the comparative results I have thus brought together; and it is no fault of mine that I am unable to place before them still more full and varied details of the relative destructibility by shot of wood and iron.

The subject, however, as every one now most powerfully feels, has passed beyond the hands of Professional judgment alone, and has become a National question, if ever a question could truthfully be so called. But the Nation and I might even add the Profession, has never been per-

mitted to be present at—but, on the contrary, has always been sedulously excluded from—every place and scene where decisions so momentous to its interests have been as yet determined; and, as it is my desire and intention to compensate this past state of things in such degree as may be done by the publication of these Lectures, I feel that I cannot shrink, even in such presence, from stating some opinion of my own on what I have now put forth. I think, therefore, that I may expect pretty general concurrence on the following view of these comparative results, viz.: That if there be indeed any difference whatever in the destructive effects shown on the one side or the other, it is so small in amount, and probably of so contingent a nature, that, to propose to base on it any conclusive decision against the use of iron, especially when taking into account its many other great and proved advantages, would be an exercise of reason but little less remarkable than that which four years previous took place in respect to the "execution" of the "Ruby." And this opinion I beg to support by pointing out that the "spread" of splinters in the case of No. 2 target, stated to have been in some cases as much as from 60 to 70 yards, must not be understood to have taken place within the limited width apart of the two sides of a ship; for in this case there was no second section, and this "spread," therefore, took place over the broad face of Portsmouth Harbour, and it was measured at distances varying from 100 to 500 yards in rear of the target. I may also observe, that the penetration of a 1-inch fir plank at a distance of 10 feet just represents the "severity" of fire of a tallow-candle. And when I further request you to note that no attempt was made or intended, either then or since, to employ the peculiar facility afforded by iron for the construction—not of screens of canvas, whereby to count the splinters after they had come in, but of *inner sides* or bulkheads of iron itself, for the purpose of keeping them out altogether,—I think I shall have put circumstances before you which will be held to justify, at least, the opinion I have expressed, even if they do not amount to an absolute decision in favour of iron.

But I have not yet finished with these "Simoom" experiments, and, as I fear I may be exciting more weariness than attention, again I must have recourse to my unfailing friend and supporter, and point out how fully Sir Howard also goes into these details, and how earnest he is in pressing attention to them; as I now do for precisely the opposite purpose; but for the very same reason assigned by him in the 173rd article of his book, viz.: "that a distinct knowledge of all the facts established by these trials is a matter of immense importance." I proceed, then, to compare the different effects produced on the firing at the two targets themselves, as elicited by the difference in their structures, and as bearing directly on that very important point in the iron question of the present day before adverted to.

Great care and correctness is exhibited in the drawings of the effects on these two targets which accompany the Report, as found in the aforesaid Blue Book, and any person who will simply put these two drawings side by side will see at a glance the remarkable difference in the effects of the shot on the target without the backing as compared with the target with it, the holes in the former case being so much larger and irregular as almost to suggest that the quality of iron in the two cases could not have

been alike. The same marked difference will likewise be seen at a glance, in the amount of descriptive writing in the case of each shot, although the difference in this respect may arise to a degree, no doubt, from the effects having to be noted for two sections in the one case, and only for one in the other. Still the differences are so apparent, if even limited to surface appearance alone, as to proclaim that iron plating backed by timber, and similar plating not so backed, present conditions of resistance to the impact of shot of marked difference in favour of that with the backing. The details do not inform us of any difference in the two cases of the force and amount of splinters, there being no second section in the case of No. 2 target; but, from the use of the modified term "considerable velocity," when speaking of the No. 2 splinters, as compared with "great velocity," when speaking of those of No. 1, I am induced to think that some corresponding effect was in reality produced by the "backing" in this respect also, although from the absence of "screens" it could not be noted.

The judgment on these experiments is stated in the Report as follows, and is still so maintained to this day:—

> The result of these experiments is the reverse of those made on the "Ruby" in 1846, a *small, slight-built iron vessel*, when the great damage was found to be sustained on the shot passing out on the opposite side to that fired at, making clear round holes only on the first side. On the present occasion, the resistance being so much greater, the principal injury has been on the front side; and the fractures made are of that description that two or three shot, and sometimes even a single one, striking under the water-line must endanger the ship. There is also another most serious evil attending this greater resistance which was not anticipated, and which has caused great surprise. The shot or shell [pray mark "or shell"] on striking are shivered into innumerable pieces, passing on as a cloud of langrage with great velocity, sufficient to pass through the 1-inch fir boards, the larger pieces going to a considerable distance (400 or 500 yards), and some through the rear section, making large irregular holes; this would be most destructive, and I firmly believe men could not stand behind it. These experiments, I consider, prove that, whether iron vessels are of a slight or substantial construction, iron is not a material calculated for ships of war.

"Slight or substantial;" alas! for the fate of poor iron: certainly, when it was sent down from London to Portsmouth, it fell among unfriendly judges. First it was so wretchedly weak, that it was knocked all to pieces by the shot; and then it became so abominably strong, that the shot were all knocked to pieces by it; and so, like the man in the fable, who was found warming his fingers and cooling his porridge with the same breath, its judges condemned it as evidently "uncanny." It would never have been released from bondage to this day, had not a certain Personage from the other side of the water "negotiated" for its free release, for his own special and charitable purposes, and so raised it from the degradation imposed by its own native-born masters.

However futile it may appear at the present day, it seems impossible not to express regret from the position we are now in, that this effect of the "Simoom" plates, "in shivering into innumerable pieces" the *shot and shell* which struck them, should have been regarded solely in the philosophic light of "another most serious evil." No doubt it was so for the "shot and shell;" but this, to them "most serious evil," was an omen of the happiest augury, for the "ship," which could not have behaved under these representative circumstances in a more coaxing manner to induce

the application of thicker and thicker plates of iron, ever breaking up the shot and shell into more and more "innumerable pieces;" and then of thicker and thicker supports of timber, ever intercepting more and more of these "clouds of langrage," until she must inevitably have gone on advancing more and more from her penetrable properties as a "Ship of Iron," until she assumed the conditions of complete practical impenetrability of the "Iron-cased Ship." And I cannot help thinking that it would have conduced more to the usefulness and distinction of our great national School for practical Naval Gunnery had the honour of this Invention, which was then so evidently pointed to in these experiments, been secured to England by her means in 1850, instead of its having been then left over for France to impose on us in 1854, and compel our now following in this grand naval Improvement the lead of our formidable rival;—at what expense, and within what time, and with what chance of taking that "lead" back again for ourselves,—who shall say?

In the "Report" we are naïvely told that the result of these experiments was "the reverse of those made on the 'Ruby;'" and that the "greater resistance" of sound plates over very rotten ones was "not anticipated," and "caused great surprise;" it is evident, therefore, that the "Ruby" flag could be no longer upheld; and, if these experiments could have furnished no other standard in its stead, the decision against iron itself must have been *reversed* too. The "un-anticipated" breaking-up of the shot was thus a real godsend, and as such must be carefully guarded, and this is also the only intelligible view I am able to take of any apparent object or consistency in the remainder of this series of experiments, which, in sole deference to the notice requested to be taken of everything connected with them by Sir Howard, I now proceed briefly to notice myself.

On the 13th of August, 1850, practice was made at a section similar in iron to those of No. 1 and No. 2, but with fir plank of two, three, and four inches thickness outside, or in front of the plates, apparently with a view to soften the fate of the shot. But there were the inexorable $\frac{5}{8}$ plates still, and, as we are told, "every shot split in passing through, those between the ribs into a few pieces only, and those that struck on the ribs into a great number." In short, the destruction of the shot was great in proportion to the substantial resistance of the plates. Then on the 10th of October following, another similar section of iron was fired at, but combined with the same composition of cork and India-rubber which had before been used at Woolwich; and again, as we are told, "the result was the same as the former trials when lined with wood; it neither prevented the shot from breaking into numerous small pieces, nor did the hole close up, as was anticipated, after the shot had passed through." From which latter remark I may presume that Sir Howard had forgotten the efficiency, for all such purposes, of his former protégé the "parasol plug."

From this time, iron plates "similar to those of the 'Simoom'" appear to have been given up as incurable, and I find that no further dealings were held with them; but a new sort of construction took place, and was fired at on the 5th of July, 1851. It is called a "butt," and was "constructed of oak and fir uprights, to represent the timbers of a ship; one half covered with $\frac{3}{8}$ and the other with $\frac{4}{8}$ sheet iron." So the shot, this time,

were to be exempted from "the serious evil" of meeting with any more ⅜ plates. But with respect to this "butt," I will request to remind you that ⅜ plating had been proved by the November experiments of 1849 to be only just musket-proof, and not canister proof; and ⅜ plates to be just canister-proof, and not grape-shot-proof, at 200 yards; while by a drawing "to scale" which accompanies the account of this "butt," I find that in a length of 14 feet there are only seven of these so-called "timbers," one only of which has a siding of 12 inches, and only one of 9 inches, the "siding" of the remaining five being 6 inches only; the "spaces" also between these "timbers," vary from 8 inches to 2 feet, whereas a frigate's timbers, besides being all of oak, would all have had a "siding" of 12 inches, with "spaces" of not more than 5 inches between them, and therefore insufficient to allow even a 32lb. shot to pass through. Accordingly, as Sir Howard points to the picture of this "butt," saying of the effects of the shot as shown upon it, that they "*sautent aux yeux*," so it may be observed that four out of the seven "timbers" escaped altogether scatheless from the fire, thirteen out of the eighteen shot fired "with distant charges," preferring to *jump* through the "butt," where they met with no more than the musket-proof and canister-proof resistance of the above thin plates. But even here the ⅜ plates seem to have left their mark on most of the shot, "splitting two" and "starring" others, so that we have here ascertained the limit of the "breaking-up" power of iron plates. The next trials, however, were so prepared as to secure the shot against even such limited maltreatment as this, and can only, with justice, be described in the following words of the book itself from which I extract them. They were made on the 11th and 12th of August, 1851, "The particular objects being to endeavour to diminish or obviate the destructive effects produced, as above, on plates of iron, by the impacts of shot, and to prevent the shot from splitting into pieces." And it will hardly be believed that the very simple and ingenious method devised for effecting these "particular objects" was that of not having any plates of iron at all to fire at; a device only to be outdone in simplicity by that of having plates of iron, but not firing any shot at all at them; but, unless I grievously misinterpret these following words, such seems to me their true meaning. "For these purposes a 'butt' was constructed to represent a section of the 'Simoom,' [another sort of side again for the 'Simoom,'] formed of iron ribs of ⅜ iron, 4½ inches wide and 11½ inches apart; instead of plates of iron, these were covered with 5-*inch teak planking* on the outside, and 2-*inch* on the inside." Not one single iron plate; and then, as if to obviate the possibility of any mistake, the description continues:—"The breadth of the 5-inch planking was 10½ inches, and of the 2-inch planking 9¾ inches." And then we find that this time the success was complete; for, although the picture which accompanies the Report shows us that four out of the seven shot would still perversely hit their heads against the iron "ribs," yet all went bounding away with unbroken rotundity, "passing on to 1300 and 1400 yards." And, after giving descriptions of the performance of each of these shot with a minuteness greater than in the case of any other experiments, we come to Sir Howard's general summing-up as follows:—"Thus it appears that the destructive effects of the impacts of shot on iron ships cannot be prevented." A truism which seems to exhibit the very same

misconception as to the object of introducing iron into the Navy which led the commander of the "Lizard" to send home his grape-shot from the Parana in 1846,—continued down, and seriously urged against Ships of that material, to the present day.

I have now, as I believe, stated most faithfully the whole case against the fitness of iron for Ships of war, as produced from experiments ordered with the view to sustain its pre-condemnation, and as contained in records openly published by its most determined antagonists; and, since my "summing up" at the period of the summer of 1846 I leave to the decision of each of my hearers for himself, how far the adverse judgment at that time pronounced has or has not been strengthened, by any one single fact elicited since the time of the *Woolwich* experiments; the "breaking-up" of the shot, be it observed, being only more fully recognised and noticed in 1850 than it had been in 1845; and its bearings on both sides of the question being fairly balanced with the wood splintering of 1838. And if I be upheld in my own judgment that that condemnation, instead of having been strengthened, has rather been reversed by the experiments subsequently detailed, then, casting into the scale, as before, the question of red-hot shot, the balance of Public decision must be, I think, not in favour of, but *against wood*, as having been proved by experiment to be an inferior material to iron for the construction of Ships of war.

But, before passing from defensive to offensive warfare, I will request you to observe of these last experiments, just as of the previous ones:—First, that many of them were of such a nature as could only be made at all under a secret and exclusive system, and could not have been even seriously proposed to be carried out, before parties representing more than one view of the "immense importance" to be attached to their results. And next, that we are all most deeply obliged to Sir Howard Douglas for having exhumed them from their 10 years' burial, and thus exposed them to a public ventilation.

But the prison-house has not yet been delivered in full; and I must proceed to do so, in the first place, on my own authority, trusting to be fully justified and supported afterwards.

Portsmouth, at the time of the "Simoom" experiments, was rife with the rumour that other most remarkable results had been elicited, besides the acknowledged reversal of those of the "Ruby;" and besides the invariable "breaking-up" of all shot. It was stated that horizontal shell-practice had also been made; and that shells of every description had been found completely inexplosive, or, in other words, that No. 1 and No. 2 targets had been found to be shell-proof. Many others besides myself made attempts to get at the bottom of this rumour; but, although it was not difficult to be furnished with any amount of fragments, to prove that the shot had all been turned into shells; what the shells themselves had been turned into seemed to be steadfastly reserved from the Public, as a subject of consideration for the initiated only. In the summer of 1853, being again at Portsmouth and in company where the subject was again mooted, I obtained information from an Officer who had been one of the shell-firers, that the rumour was a reality, and every detail was then given me of the facts; but, however desirous of giving them publicity, under a strong sense that a most important National interest was

involved in them, I felt that, if challenged for my authority, I must either decline to give it, or do so to the probable injury of my informant, and I therefore refrained. In the beginning of 1854, however, shortly after the outbreak of the Russian war, chance gave me what I had so long desired; and at another "United Service Institution," not 100 miles from the one we are now assembled in, I was made master of every fact, and even opinion; with the most complete unreserve; and by one who was necessarily as cognizant of the whole matter as any other witness whatever to the experiments. This was the statement: that, being in the boat, lying obliquely in rear of the target, for the purpose of noting the effects of the shell-firing, attention was first attracted to the very different sound produced by the explosion to that generally heard; still the shells evidently burst, for there went the pieces all over the water. Then the further remarkable fact was observed, that the smoke of the explosion, instead of being white, was perfectly black; and, as these phenomena occurred as each shell was fired, examination was at length made, and it was discovered that the shells had not burst or exploded at all, but had, like the shot, been broken to pieces by the plates, the pieces passing through them, but the powder of the charge being dashed against the plates into a cloud of black smoke. In reply to inquiry, I was told that this was the case with every shell fired, whether "time fuzed" or "concussion," and that the targets were in truth found to be "shell-proof." And further, in answer to a few practical questions, I found that the conclusion held to be established as the direct result of this portion of the entire series of experiments—for they were far more continuous and extensive than is shown either in the Blue Book or Sir Howard Douglas' work—was this, that shell-firing at ships of iron, with sides of $\frac{5}{8}$ plates and upwards, was to be avoided as worse than useless, the shells being as harmless as if charged with sawdust instead of gunpowder, and being nothing more than very expensive and very bad shot. But my informant added, that the injury to material and life in a ship of iron, resulting from a fire of 8-inch and 10-inch hollow shot, would be greater than could be effected on a ship of wood by an equal fire of 8-inch and 10-inch shells; a view of the case which I could accept only as an opinion which never had been, nor has been substantiated, by any comparative trials to this day; but, as he expressed himself content to command in actual fight a ship of wood, although liable to all the destructive effects of shell-fire, I could but accept the amicable challenge by expressing myself equally content to try issue with him in a ship which was liable to no such treatment at all. I will here add, that on subsequently meeting the brother Officer to whom the Country is so much indebted for the present naval "concussion" shell, and whose untimely loss is so generally lamented throughout the Service, a similar conversation on the same subject took place, and with precisely similar conclusions expressed on the same facts, except, that having been himself one of the firers at the targets with his own concussion shells, he thought that in one or two instances explosion had taken place. I now felt myself able to meet any challenge as to "authority," and throughout the latter part of 1854 made every attempt to procure a reconsideration of the whole subject, and induce a series of fair, open, comparative, and conclusive trials

by trying through all channels open to me to procure publication of the following letter:

ARE SHIPS OF IRON UNFIT FOR THE PURPOSES OF WAR?

SIR,—At a time when all the available resources which England possesses will so evidently be required to support the present war, I beg to request the insertion in your colums of the following observations; which I thus publicly submit, in the hope that they may lead others also to reconsider that decision which at present debars our country from employing her ready stores and workshops of iron; and limits her to the use of wood alone for the construction of all "Vessels of War."

That decision is the result of experiments made at Portsmouth in 1850, by firing at iron targets $\frac{4}{5}$ths of an inch thick, representing a portion of the side of the "Simoom" then our largest iron ship; the effect of which targets was, (as a rule,) to break into pieces whatever shot was fired against them; which pieces of shot, together with the pieces of the target where it was struck, passed through and were scattered about on the other side. Thus showing that the crews of guns fighting behind the side of ships of similar construction would be exposed, on receiving each shot, to a deadly shower of pieces of iron, insomuch that it has become usual to express the condemnation of such ships for the purposes of war by saying that "every shot which strikes them becomes a shell."

But the same experiments also elicited another fact, equally important and remarkable, the knowledge of which has recently been acquired from a perfectly authentic source. A fire of horizontal shells was employed, as well as that of shot, against these targets, and the effect of the targets was to render the shells *inexplosive*. The shells, like the shot, were broken into pieces; and the pieces, as before, passed through and were scattered on the other side: but, throughout the first experiments (with concussion shells), and, so far as can be learnt, throughout all subsequent experiments, no shell was found to explode against these targets; the shell itself being broken to pieces, and the powder which filled it being dashed into a cloud of black dust against the face of the target—apparently before it had time to ignite.

Subsequent inquiry has only led to the statement that the shells thus, I may say, emasculated, were not "concussion," but were "time-fused" shells. But, as this statement confirmed the fact of the non-explosion, and from full information completes the application of that fact to both description of shells, it would seem that the two most important results derived from these experiments might at first sight be marshalled with equal effect on the opposite sides of the question, thus.—Condemnatory of iron ships:—"Every shot striking a ship of iron $\frac{4}{5}$ of an inch thick becomes a shell." In favour of iron ships.—"Every shell striking a ship of iron $\frac{4}{5}$ of an inch thick becomes inexplosive."

But is it indeed correct to pronounce that a shot becomes a "shell" if fired against an iron ship, merely because in these experiments shot were found to break into as many pieces as when a shell explodes? The shot was thus broken by great *external resistance*,—a resistance greater, if measured by this effect, than shot was ever exposed to, before being thus fired against plates of iron; and in direct proportion to this resistance must be the reduction of the shot's momentum, and therefore of the inherent power of its several fragments to do mischief. But when a shell explodes it is broken into pieces by great *internal force*—a force which goes to renew, if not to increase, its powers of destruction, even if the shell have already come to rest;—a force which thus gives to each fragment the character and effects of a separately discharged missile, in addition to the mischief the shell may have done before it exploded, and to the great destruction produced by the explosion itself. It cannot therefore be maintained as correct, either in fact or reason, that a shot, when fired at an iron ship, should take rank among destructive missiles as if it were a shell, merely because the resistance opposed by that ship is sufficient to break the shot into as many pieces as a shell when it explodes.

Neither will experience allow that a shell, if emasculated or deprived of its powers of explosion, should rank among missiles as if it were equal even to a shot; because a shot whether hollow or solid, is heavier than any shell of equal diameter even when loaded, and therefore at equal velocities is armed with a greater momentum for mischief; so that if a hollow shot and a live shell, of equal diameters, strike an iron ship at equal velocities, and both be thereby broken into an equal number of pieces (the shell becoming inex-

plosive), then, the momentum of the solid shot being greater than that of the shell, the power of both itself and its fragments to do mischief will also be greater. If, then, we now suppose the two rival materials of construction to be called on to arm and prove their relative fitness for "the purposes of war" by the ordeal of actual contest: we should certainly see the ship of iron firmly adhering to the use of the shell, as the most destructive missile ever launched against sides of wood: while the ship of wood would most probably select the large hollow shot as the most effective missile for shattering the opponent sides of iron, and so producing with its own broken pieces the deadliest shower on those who fight behind them.

I would here point out, that the decision of the present day against ships of iron is based on results entirely distinct from those which were urged in condemnation of them *prior* to the experiments at Portsmouth of 1850. It was formerly assumed that iron plating could be so rent and destroyed by shot, that any ship so constructed must in action be speedily and inevitably sunk. More extended and correct experience has shown, however, that the condemnation could not be sustained upon these grounds, and that the effects of shot upon sound and substantial plating seldom, if ever, extend beyond the part actually struck; even the sides or lips of such wounds remaining perfectly sound, and affording the most ready and solid basis for at once applying the means of temporary stoppage, or permanent repair. Therefore it is important to remember that the condemnation of to-day does not depend upon objections urged against the destructibility of the material itself, as formerly, but that it proceeds upon the assumption that a greater loss of life must be sustained in action on board an iron than on board a wooden ship. So that while our two belligerents, as above, may be supposed to be preparing for actual blows, it may be well to examine their respective prospects of success by this standard of probable comparative slaughter.

In the Portsmouth experiments, a screen or screens were suspended at a certain distance behind the iron targets, that the piercing of these screens might give a just view of the number, size, direction, and force of the several fragments of iron scattered about at the striking of each shot; and the results thus accurately ascertained and recorded constitute the *gravamen* of that charge of "unfitness" so tritely expressed in the terms I have ventured to criticise above. But it is evident that the question to be thus determined was one, not of an abstract, but entirely of a comparative nature; and if to be determined therefore by any peaceable experiments at all, such experiments should have been, not merely abstract, but *comparative*, and in all respects equal.

It is therefore greatly to be regretted that the same simple and effective method of the screens was not also employed for ascertaining the correct amount, &c., of fatal or disabling splinters to be produced from a target representing in wood, a similar portion, of a similar sized ship, subjected to a similar fire of shot and shell: since, however deadly may be the iron shower to be sustained behind walls of iron from a fire of shot—if the mixed shower of wood, and iron, and destructive explosion too, to be sustained behind walls of wood from an equal fire of shells had been proved to be more deadly still—then the Portsmouth experiments must have failed to support the condemnation of iron ships on the ground of their causing a greater loss of life than ships of wood, just as those same experiments did contribute so largely to break down the prior condemnation of iron, based on its supposed greater destructibility. In the absence, then, of all equal and comparative trials, the points under examination must be determined by each party according as his judgment may have been formed from the facts elicited by the Portsmouth experiments on iron, compared with any shell-firing against wood which he may have witnessed or known, either at that place or elsewhere;—bearing in mind, however, that the comparative numbers who may be placed *hors de combat* by wounds are equally conclusive, as to the results of any particular engagement, as are the numbers of the actually slain: on which principle the shell-firing at wooden ships which I have myself witnessed at Portsmouth bids me believe that it must prove quite conclusive *against* that material, and those sheltered behind it, as compared with iron. It is, I believe, an under and not an over statement to say, that an 8-inch or 10-inch concussion shell, exploding in the side of a wooden ship, will more or less destroy it to the average extent of four feet square, and that the mass of splinter thus produced will more or less disable all who come within its sphere; while the destruction to be produced by horizontal "time-fused" shells penetrating and exploding within the ship has recently been most severely illustrated before the walls of Sebastopol. And such effects as these, especially as regards destruction of material, cannot, I believe, be equalled by a similar or any other known description of fire, directed against even $\frac{3}{4}$ iron. Wherefore, upon all these grounds,

and relying on the authenticity of the non-explosion of shells against the targets at Portsmouth, those very experiments may be appealed to, to justify the conclusion that the relative prospects of our two supposed belligerents now ready to engage will stand thus:—

If two equal ships of any size—the one of iron, the other of wood—be brought into action against each other, both being equally well manned, commanded, and fought, the iron ship using the concussion and "time-fused" shells as her most deadly missiles, and the wooden ship using hollow shot of equal diameter as her most deadly missile: then the wooden ship must either yield to the iron one, or be entirely destroyed. And this conclusion must, I believe, have been established by the said experiments, if a target of wood similar in strength and size to the target of iron had been exposed to a similar fire: because the most remarkable feature exhibited by the last of these targets before it was taken to pieces was its still comparatively perfect state, after receiving an amount of shot and shells a portion only of which must, I think, entirely have destroyed a wooden one.

It is equally to be regretted that these experiments also fail to furnish information on the ability of iron plating to sustain a fire of hot shot,—a trial from which the targets appear to have been entirely exempted, but one which might have had a direct bearing on very important questions of the present day. The two special advantages now possessed by stone walls over wooden ones, which are at once the most insurmountable and conclusive in their favour, consist in the fire of shells and red-hot shot,—which being of the most destructive nature as directed from batteries against ships, are at the same time of the least destructive nature as directed by ships against substantial batteries (I do not include mortar fire). But the Portsmouth experiments, which have shown that the plates of an iron ship are able to reduce a shell-fire to a smaller destructive effect than a fire of shot, *might*, had they been so extended, have also shown that they could reduce a fire of red-hot shot to be equally innocuous. It is the lodgment of hot shot in the solid timbering of the side, and the difficulty of either extracting or cooling it there, which constitutes its chief danger to ships of wood: and from this danger it is clear that an iron side is free. The hot shot, like the cold one, would doubtless penetrate such side; but in doing so would it not be broken into smaller fragments still, the power of cohesion being reduced by the heating? And if this were so, then these smaller fragments must certainly cool down sooner than larger ones; and the open deck, where they would fall under observation and treatment, would seem to be their principal sphere of even this limited mischief.

But there is no need for the aid of conjecture. Enough has been said to show that the Portsmouth experiments, important as they were, were yet so incomplete in themselves, and admit, now they are known, of such opposite conclusions being drawn from their results, that they cannot be admitted as a satisfactory or final settlement to a question of such grave moment. They impose at this time a complete barrier against the employment of resources which it may be of the greatest advantage should, at least, be ready to be called forth; for not a gunboat can be built of iron whilst the decision of these experiments proclaims that all who serve in her must be exposed to a greater sacrifice of life than if she were of wood: whereas, I have endeavoured to show that there are substantial grounds for belief that an open, complete, and comparative system of experiments would establish the *superiority* of iron over wood for the "purposes of war," both as regards its greater indestructibility and its greater protection to life; and I need not observe, if such prove the case, how great an addition would at once be gained to our available resources for war—and doubtless not in gunboats only.

I am aware that, even in such a case, time alone could bring about the employment of iron for the construction of the larger ships of war; but time is also precisely the very remedy required to abate and remove prejudices; to acquire experience and confidence; and to complete those changes and additions, which the extensive use of that material would doubtless call for. But such changes would be no greater, if so great, as many which this age has already seen and now greatly benefits by; neither would the additions be greater, if so great, as those which have been requisite for the somewhat cognate purpose of converting the whole British Navy into a "Screw Fleet." In such case also, there would still remain, *at present*, the very grave objection against iron bottoms, of their liability to foul, and the consequent frequency of resort to the operation of docking. But has not the barrier I seek to remove been a chief cause why this grave objection *does* exist at present? Could there have been a greater discouragement to deter eminent talent from devoting its attention to remove this objection than the knowledge that if removed there remained an impassable barrier still, to prevent the advantage from having any practical application to our great "National Fleet?"

I have thus endeavoured to submit my views on this whole subject firmly and clearly, that my purpose as at first avowed should admit of no mistake; and I have done so thus fully, because it is my intention not to enter into any controversial correspondence. It has also been my endeavour to write—not dogmatically, still less offensively, to the most sensitive of those who, like myself, exercising an independent judgment, may choose to think differently on a matter of such national interest. Need I add, finally, that I should be unworthy of my Profession if, in thus writing, I could be charged with any want of true allegiance to the ennobling history and traditions of our "Wooden Walls." It is, however, a plain fact, that those "walls" have long since ceased to be built to any great extent of "British heart of oak," while supplies of foreign growth are gradually becoming more difficult and expensive. Wherefore I believe that I am no "recreant," either to my Country or my Profession, because I avow both my hope and conviction that the noblest and most natural substitute to be found for "British oak" exists everywhere around us in our stores of "British iron."

Such, then, is my own, and, as I believe, the only statement of a personal nature I shall have to make throughout the more historical portion of these Lectures, and the necessity for having done so, even in this case, will presently become apparent, as a means of rendering more intelligible the obscure manner in which this most vital point in the whole question, namely "shell-fire," has been referred to in any published records; but by which, nevertheless, as I now proceed to show, every particular stated to me is fully substantiated.

In the Report of musket, canister, and grape shot experiments of 1849 I find this sentence in the summing up:—

Iron offering no lodgment for shells on passing through the side, if made with single plates, it will be free from the destructive effects that would occur by a shell exploding in a side of timber.

A remark which I cheerfully accept, as showing how keenly understood was the importance to either side of the question, which could establish any difference in its own favour in respect to shell-fire. This sentence, however, is limited to the superior security of "ships of iron" against the *lodgment* of shells in their sides; but in the Blue Book Report of the firing at No. 1 target we are told—"The shot or shell on striking are shivered into innumerable pieces." And just in a corner of the details and plan which accompanies this report I find this very unostentatious note: "Six 32-pounder shells were fired—two burst, four broke." Not, be it supposed, that this represents all the shell-firing which took place, any more than that the picture of the target shows all the effects of all the shot-firing; for these targets afforded practice for months, and, when done with, scarce a hand's breadth of sound plate could be found between the shot and shell holes; and yet I am assured these targets were still perfectly capable of repair. So that the statements of the Blue Book itself, besides establishing the non-lodgment of shells, amply corroborates that shells were fired, and that they were broken into those "innumerable pieces on striking the plates which produced on them all the effects of emasculation; and the only point which in principle the Report itself omits is that of telling us what became of the powder. But may it not in truth be matter of surprise to find this Report telling us so much, instead of so little, when it is considered how obviously the experiments must have been ordered, not for the purpose of "reversing," but of supporting those of the "Ruby," and that, by the *wording* itself of the Motion

for the Return, though made twenty-four days after the date of the Report of the firing, its demand is limited to the "effects of shot" only?

Still, I cannot feel satisfied without the support of Sir Howard's important book, and it is astonishing how reluctant that book seems to be to give it. In collating the detailed account of the No. 1 target-firing, with that contained in the Report about the same target, I find these words —"Another most serious evil is, that the shot breaks on striking into innumerable pieces;" overlooking altogether the "or shell" of the Report itself, from which, nevertheless, the sentence is so evidently taken. And I am equally foiled again on searching through the "Conclusions" stated in article 454, which I find are directly derived from the list of "preceding experiments," all of which were made on "armour" plates, the thinnest of them being $1\frac{1}{2}$ inch thick. I then turn to the "Postscript," which contains two tables of shot and shell practice at plates—one on pages 12 and 13, and one at page 60; but the thinnest of these plates, again, is $1\frac{3}{4}$ inch thick, besides that the experiments detailed are all of dates much more recent than those of the "Simoom." At length, at page 15, I find a repetition of those same "Conclusions" set forth in the main work, but with some alterations, and in the second of these I find as follows:—

2nd.—*That thin plates of wrought iron even $\frac{5}{8}$ of an inch thick* [mark, even $\frac{5}{8}$ of an inch thick] *are proof against shells* or hollow shot in an unbroken state, but that the fragments of the shot or shell pass through the plate, and produce an effect perhaps more formidable than any shell.

Now this is exactly what I have been looking for, and I at once proceed to appropriate it as my "choicest weapon." I eliminate the latter part of this "conclusion," by observing that it is no part of any conclusion at all, its basis being nothing more substantial than a "perhaps." And I proceed to illuminate the obscure expression "in an unbroken state," by translating it into its plain English meaning, thus: "That a shell, in order to be such, must be "unbroken" by anything but by the explosion of its own charge;" the corollary of which is, that when shells are fired at substances which break them up "on striking into innumerable pieces," dispersing to the winds the powder of their charge in a cloud of black smoke, they then cease to be shells altogether, notwithstanding that such of their pieces as have a force equal to that of a grape-shot may pass through the substance which inflicts on them "this most serious evil," and this corollary Sir Howard himself undoubtedly applies in those first 16 words of his above "Conclusion."—Not a mere account, be it observed, of a single, or even of "six," individual instances of the sort, but deliberately set forth by our great Artillerist as arrived at by him.—How? "After a close examination of all the facts established, and the results obtained from these experiments." What experiments? The "Simoom" experiments. Why the "Simoom" experiments? Look through every page of Sir Howard's "book" and "postscript" too, and see where you can find any other shot or shell experiments made at $\frac{5}{8}$ plates, except those he declares to be of "such immense importance," and which he therefore so minutely describes as having taken place at Portsmouth from 1849 to 1851, at the many-sided "Simoom."

And now I proceed to apply Sir Howard's weapon in breaking down

therewith his own position and in establishing mine in its stead, taking as exponent this very "Simoom" herself, the ship built "wholly" of that material pronounced perfectly unfit for all the purposes of war.

At page 256 of the "Naval Gunnery" may be read a graphic description of the effects of an accidental shell explosion on board the "Medea," in 1840, whereof it is said, "These are portentous proofs of the terrific effects, physical and moral, produced upon a ship by the explosion of shells at rest within her, *and the like effects must be expected to ensue, should an enemy's shell be planted or lodged in the ship before the explosion takes place.*" From which "terrific effects," the "Simoom," as a ship built "wholly of iron," is doubly secure.—First, as the Blue Book Report states, because "iron affords no lodgement for shells;"—and next, because, as Sir Howard's book tells, "thin wrought-iron plates, even $\frac{3}{8}$ of an inch thick, are proof against shells."

And now from contingencies to realities; at page 617 may be read,—

> The damage sustained by the combined fleets was caused chiefly by the Russian shells, which were fitted with time-fuzes, as were those which they used at Sinope. The "Albion" received several shells close to the water-line, three entered the cockpit, and she was once or twice on fire. Having ceased firing in consequence of being compelled, when on fire, to close the magazine, and having signalled for the assistance of a steamer, the "Albion" was towed out of action stern foremost, by the "Firebrand," in effecting which both vessels were severely damaged. The "Arethusa" was set on fire several times, and severely damaged by the Russian shells. One burst on the main deck, and knocked down a considerable number of men of the adjoining guns' crews; another shell burst on the lower deck, and set fire to some material close to 200 live-shells placed there for immediate use! Another shell blew out portions of several planks in the bends, and had there been any sea the ship must have sunk. A shell lodged and burst in the timbers at the water-line. An officer and five out of seven men standing together on the upper deck were dangerously wounded by the bursting of a shell. After having retired out of fire it was found necessary to heel the ship to plug shot-holes below the water-line. The "Sans Pareil" suffered severely in men and spars. The "London" suffered considerably in her hull from shot and shells fired from the Telegraph Battery, and was three times on fire in two hours. The "Queen" was also forced to withdraw, a red hot shot having set fire to her.

From all which effects actually sustained by ships built of that material judged to be best "fitted" for all the purposes of war the "Simoom" must have been shielded under Sir Howard's ægis, that "$\frac{3}{8}$ plates are proof against shells."

Let us now turn to another modification. At page 35 of the Postscript may be read:—

> The affair of Sinope was much more serious. The whole of the Turkish squadron was burnt by firing time-fuzed shells into them, from which they were set on fire from the ignition of powder circulating on the fighting decks, and which, there is no doubt, produced so much panic among the crew that they were unable to extinguish it.

Here, again, Sir Howard's ægis shields the "Simoom," as a ship built "wholly of iron," from the fate of the Turkish frigates.

But to bring this practical difference between wood and iron as the material for ships of war into still clearer comparison. If the frigate "Simoom," built "wholly of iron," had been alongside her sister frigate "Arethusa," built "wholly of wood," receiving, in sympathy, shot for shot, and shell for shell, in the same places, would she also have been "set on fire," by shell explosion, "near a store of 200 live shells?"—would she also have had "several planks blown out of her bends," so that "she

must have sunk had there been any sea?"—would another "shell have lodged and burst" in her timbers at the water-line also?—would she also have been compelled, from these and such like causes, "to retire out of fire?"—and would it have been "found necessary" in her case also to "heel the ship in order to plug the shot-holes below the water-line," more than it had been found necessary to do so, eight years before, when the little "Lizard" secured the leaks from her seven shot-holes "below the water-line" with Sir Howard's "parasol-plug?"

But one step closer still in this practical comparison. How would it have fared differently with the "Arethusa" herself, and with all her wooden friends and allies at Sebastopol? How with the Turkish frigates at Sinope? and, on the other hand, how with the Russian foe, in both cases, had each wooden side been closely clothed with Sir Howard's shell-proof ægis of a $\frac{3}{8}$ plate of iron, or more?

And to move on from the past, to the present and the future,—not from Moorsom to Martin, not *from* the explosive shell *to* the shell incendiary, but to explosive and incendiary shells combined. And who can fail to see that the first half-dozen of each which can be "planted or lodged" by the ship built "wholly of iron" in the sides of the ship built "wholly of wood," must convert her, not into "lucifer matches" certainly, but only because even lucifer matches cannot be converted out of ashes? And on this inevitable deduction from what we have now been enabled for the first time to put together I declare my own conviction that, in the event of war, every ship of wood, being of sound material and capable of bearing the weight, which shall not be clothed with Sir Howard's ægis against explosive and incendiary shells, spherical and conical—in other words, with iron plates varying from $\frac{3}{8}$ inch in the one case to $1\frac{1}{2}$ inch in the other—as stated in article 446 in these words—

> No shell penetrated in an unbroken state, and did not therefore show the effects that a live shell would have produced by bursting between the decks; or, what is still more destructive, lodging in the side and there bursting.—

Every ship, I say, so unclothed, and coming to grief accordingly, must have that grief, however humiliating, attributed to the want of due and serious consideration of that which practical proof, as well as experiment, has now bid us to know. And the awkwardness of thus building "ships of wood" first, and then building over them, as it were, ships of iron afterwards, however inevitable at present, points to the equally inevitable deduction for the future,—that no ship, of whatever size, intended for "purposes of war" ought ever to be built wholly of wood again.

I will just try to support this conclusion at once by the following considerations of a more peaceable nature, inserted as an episode on—

"*Strength of Structure.*"

By the Parliamentary Return of the mercantile Steam Fleet, made up to the beginning of 1860, I find that out of the entire number of 1,863 British registered steamers, 862 are of wood, while 1,001 are of iron. Of this whole number, again 1,291 are paddle vessels, and 572 are screws; and while of the paddle vessels 729 are of wood, and only 462 of iron; 539 of the screws are of iron, and only 33 of wood, sixteen of which are

under 100 tons gross burthen, four of 500 tons or more, and only two of the gross burthen of above 1,000 tons. And the practical cause of these latter proportions of wood and iron I illustrate by the following statement:

Not long ago a company of shipowners (Foreigners, for English merchants would not be found foolish enough,) built a fleet of first-class wooden Screw-ships to perform regular Transatlantic voyages. These ships were built by one of the most reputed Thames ship-builders, and supplied with the engines and boilers of a most distinguished Engineer. The Company started their fine fleet with a Government Mail Contract, and everything in their favour. It happened three years after they started that I was called upon professionally to make myself acquainted with the fact of the entire failure of the Company, and to report on the value of their fleet. I found that they had carried large and remunerative cargoes; that they were full of passengers both ways; that their revenue was larger than that of any profitable working Company in England in similar circumstances with which I was acquainted. At last, in the "Bills for Repairs," and the losses by delay and by damage, the whole mystery was solved. It had been found impossible for the ships to make two successive voyages across the Atlantic without receiving afterwards a thorough repair, or leaking so badly as to damage the cargo. When I saw them I was obliged to recommend my friend to have nothing to do with them on any terms, as to run them would be certain ruin, and they have accordingly not been running since.

And now, to apply these facts to our own Navy, what have we to rely upon, under the similar circumstances of continual work, which in war will be inevitable, that the wooden frame of the Screw-ship of War will be better able than the similar frame of the Screw-ship of the Merchant to endure the continued stress of its own machinery? I will acknowledge superior care of construction; a better selection of better material; and even superior shipwright carpentry; but are these more than sufficient to compensate for the heavier stress arising from far greater topweight of structure, and of masting, together with great weights of artillery, all operating above the centre of gravity, to be added to the effects of far more powerful machinery below? For if they be not *more* than sufficient to compensate these special burdens on the frame-work of the Ship of War, then in due course, "successive transatlantic voyages," or, in other words, the constant sea-going of War-service, must produce on the wooden frames of the Fleet Royal of England precisely that same state which the same work did produce on the wooden frames of the Fleet Mercantile of the Foreigner. Let us then see how far we have any indication that this more than sufficient strength of structure to meet the special stress I have pointed to does really exist. On a trial, in the basin of Sheerness, of the 600-horse power engines of the "Edgar," a perfectly new 90-gun ship, the whole stern-frame was so sensibly put in motion, and the caulking so entirely driven out in streamers from every seam, by the action of the screw, that it was only under the emphatic demand of the chief Shipwright Authority, "For God's sake stop those engines, or you'll drive the sternpost out of the ship," that serious mischief did not occur. In the case of the "Nimrod," also a new vessel, the same effect on a similar occasion took place, and a proportion of her steam-power, and therefore steam-speed, was removed. In the cases of the "Queen" and "Trafalgar," both razeed into Screw-ships from sailing three-deckers, the same effect on their new stern-frames was produced, though to a less degree; not on trial of the engines in the basin, but on the trial itself of the speed of the ships outside. And what in these, as in all the other circumstances and similar cases is, and always has been, the remedy applied: more wood?

not at all; but the wood-work which "is," carefully examined to see how much more "iron-work" can be brought to support it. So that we are perfectly aware we are building our ships of two materials, the distinctive properties of which are, that the one is too weak for the purpose, and the other amply strong: and that our only hope of getting the entire structure to do its work at all, depends upon the amount of the strong material, which, by cunning device, can be embodied into a support for the weak; but a small portion of such "cunning" being sufficient all the time to enable us to build of the strong material altogether. But, I forgot; yes; there are the experiments on the "Ruby" and the "Simoom" to tell us, that shot can only make holes in ships of iron, and that ships of wood can make no splinters!

And now to apply these facts to some particular case; let me ask with respect to our Frigates, of which we are so proud; our screw-frigates of from 600-horse power to 1,000-horse power, our "Immortalités," and "Ariadnes," and "Merseys," and "Orlandos;" who knows whether they are or are not "frigates" at all? I speak of their substance, not of their show; the beauty of which, like all the rest of the nautical world, I deeply admire. But "frigates are the eyes of the Fleet," and in proportion as the Fleet itself, by its superior powers of locomotion, is able to extend the limits and sharpness of its own eyesight, by so much must its auxiliary "eyes"—in order to be as useful as formerly—be sharper and more ubiquitous still. And for this they are accordingly provided; but this provision has never yet been proved; for I doubt if it can be shown that any single frigate of the steam-power I have named has ever yet tested the ability of her frame to bear the stress of her machinery *at full work* for any forty-eight consecutive hours, perhaps not even for any twenty-four. May it not be well then that we prove our armour of this description before the day of battle actually arrives; since, to defer the first proof of it until then cannot be wise, and may be found not a little hazardous. I venture then to suggest, that some 600-horse-power frigate be put to test, by a "Transatlantic voyage and back;" a single and a short comparative proof of what such ships ought for their cost to do. Let her fill up with fuel at Plymouth, and steam at Full-speed direct to Halifax and back again, under the assumption of most important State interests, connected with the present disturbed conditions of our Republican relatives. Whatever be the full stowage of fuel, let the first two-thirds of its amount be shown by the "Register" to have been expended each way in continuous work at Full-power; and, as no frigate ever yet built in England carries fuel for 2,000 miles "full-steaming," let the remaining one-third be economized, so as to complete the two passages "under Steam." All Sail to be used, with whatever amount of Steam, whenever practicable. Let an 800-horse-power specimen, and a 1,000-horse-power specimen, follow in due course, and on the same terms; and then, on the same terms, put forth the powers of the "Himalaya," over the same race-ground, that the value in work; the cost in price; and the casualties in repair; may be publicly seen in a case of the same work, done by wood and by iron. If it be said that the "Himalaya" is of a superior form for speed, and of a less bulky material of construction; the answer is, that the inferior form for speed of the ship of wood, and the bulkier

material of construction, have both been matters of deliberate choice; and it is the wisdom of this choice which is precisely the object to be thus practically tested. The "strength of structure" of the "Himalaya" has been proportioned to the work intended to be performed by her, as is that of the frigates intended to be proportionate to their work, and long ere now the "Simooms" and "Vulcans" of 1845 must have grown into 50-gun frigates, and most likely *into line-of-battle ships too*, but for that violent and sudden action of 1846, which crushed the steady progress of professional improvement.

But to resume this part of my subject, and in respect to any supposed inconsistencies of the title of these Lectures with what I have hitherto put before you, permit me now to bring to your notice how intimate is the connection—nay, the very existence—of the quondam condemned "Ship of Iron" with the present approved "Iron-cased Ship." Let me show you that the latter is but the former with its coat of armour on; just as formerly the "man," became the "man at arms" by precisely the similar process of donning his suit of mail. In building the "Warrior" and all her congeners, we have simply again built "Simooms;" larger and stronger, no doubt, than the prototype of 1845, just in proportion as 6,000-ton ships, and 4,000-ton ships, are larger and stronger in all parts and proportions than ships of only 2,000 tons, and also, no doubt, with the requisite additional strength and arrangements to enable the 1,300 tons of the armour and its wooden "padding" to be duly carried; but, with these modifications, and with whatever improvement the past fifteen years has wrought in producing the material, and framing the construction, there, in each case, is the condemned "Simoom" of the summer of 1846, dignified into the "Iron-cased" "Warrior" of 1860. And in this instance, as also in those of the "Black Prince," "Resistance," "Defence," and the ship to be built at Chatham, the identity in respect to fitness for the "purposes of war" is even closer than the identity in construction of hull. Whoever will look at the picture in the Blue Book of the effects of the firing at No. 1 target of 1850, not No. 2, will there see, and may there read of, precisely the very same effects as must be produced by shot and shells and grape, and 10-inch Paixhans too, whenever the "Warrior," or her sisters, take into the thickest fight, not their own special armoured sides only, but those identical unarmoured ends sides of the "Simoom," which constitute an inseparable portion of each ship I have named, to the extent, in round numbers, of one-quarter the whole length before, and one-quarter the whole length abaft that portion, which alone is armoured, and which thus occupies, roundly speaking, but one-half the entire length of the ship: and whatever circumstances of condemnation, or of justification, in the employment of such plates for "ships of war" may have been elicited and determined, out of the only experiments which have ever yet been made on any such plates at all, must of necessity apply as faithfully and as directly to the above portion of the sides of all these semi-"Simooms," as they applied to the entire sides of the original Ship; with this difference, however, in favour of the original, that the sides of these more modern "Simooms" have the backing or timbering omitted—

but whether for the same reason as is given in the Report of the firing at No. 1 target, I cannot say. But does not that Report, it will be said, pass an unqualified condemnation on the employment of any such $\frac{5}{8}$ plates, and even say of the "large irregular holes" made through them; and of "the clouds of langrage" produced from the splintering of the shot by them; that it is "firmly believed men could not stand behind them?" Certainly it does. And is it possible that the one-half, in round numbers, of the sides of five out of seven of our "Iron-cased Ships," representing an aggregate cost of not less than 1,500,000*l.*, are constructed out of these condemned plates of 1850? Certainly they are, unless where the plates are $\frac{6}{8}$, instead of $\frac{5}{8}$ thick, in which case the shot or shell will be broken up into rather more splinters still. And were there no circumstances elicited out of the experiments of 1850 which could compensate for the destructive results produced by firing at such plates, and thus justify their employment to so large an extent in these most costly ships? Search carefully throughout the "reports" and "details" of the Blue Book, and throughout all additional details given in the work of Sir Howard Douglas: it is an important search; for whatever can there be found to justify the use of such plates of iron now, must necessarily have justified their use then; and whatever can there be found to condemn their use then, must equally condemn their use now. I can find no word of justification for the use of such plates in the works referred to. Can you suggest none other which may afford more success? None other, unless it be in Sir Howard Douglas's recent "Postscript," and in those sixteen mystical words contained in his second Conclusion, in the fifteenth page: "That thin plates of wrought iron, even $\frac{5}{8}$ths of an inch thick, are proof against shells." If those words do not contain the justification sought for, then is the use of such plates in the batteries of such ships at all, *utterly unjustifiable* but if they do contain that justification of their use in 1859, then do they with equal force overthrow the condemnation pronounced on those same plates of iron in 1850. I feel I can add nothing to the force with which truth has thus vindicated itself;—nothing to this entire justification of the long-slighted memory of Sir George Cockburn;—to this tribute to his far-seeing sagacity, and the establishment of his unimpeachable title to be regarded as the "Father" of our iron "Fleet of the Future."

Thus I have been brought safely through all my own conclusions chiefly, I may say, by those of Sir Howard, and in now taking grateful leave of him with the same respect and honour as that with which I commenced our "amicable differences," I again presume to express my sense of what I believe to be a deep public obligation in the means which his research has afforded for an entire review, and as I trust I may say redecision, of this great question; and in which, if it result in public benefit, I again repeat my sincere conviction that none more than Sir Howard himself will rejoice. And I may therefore now proceed to avow what has been one primary object in undertaking this review at all.

I have long felt that "Iron-cased Ships," although destined, as I believe, to supersede, as chief exponents of "naval force," at least the wooden Screw-ship-of-the-line, were, like them, unfitted by bulk and costliness to perform all the various duties of British men-of-war throughout the

world's waters ; and yet, that to continue the building of ships wholly of wood, even for the performance of these more general duties, would be, in the face of the present features of modern artillery, to build them for certain destruction. It therefore appeared to me very desirable to attempt the removal of those obstacles to A GENERAL USE OF IRON FOR OUR FLEET, which I have ever regarded as being in themselves purely fictitious. How far I may have succeeded, or may succeed, in effecting such removal, now remains, of course, for the action of that "opinion" to determine, but I have faith that I have done so at least to this extent, that any reasonable doubts or misgivings yet remaining, will be found entirely to disperse before any well devised, faithful, and open experiments, that may be directed towards doing so.

At this point also I claim to have vindicated the National recognition of the value of our iron resources for every maritime purpose. I have endeavoured to show, not I trust presumptuously, that in the assumed unfitness of iron for "purposes of war" as well as commerce there has indeed been no anomaly in the gifts of Providence, and in the mode of maintaining that assumption, none, alas, in the frailty of man. And I have exhibited how great is the power of our present system of "secret and exclusive experiments" on great national objects, to set up and to pull down; to uphold and to withhold; and to reverse, wholly or in part, any required thing.

And now permit me to remind you of two things. First, that the main course of my history is not yet brought to its close, it having been quitted for a time in order to trace out to its conclusion the "Simoom" branch ; and next, that this branch itself has not been traced to those natural conclusions so inevitably to be drawn from the features it presents. Were I fully to do so, I should have to enlarge on the equally ungrateful task to both of us, of pointing out how the most valuable truth of the "Simoom" trials, that truth which badger-like had to be drawn forth out of Sir Howard's little six-word sentence, still continued to be rigidly withheld from public light, *and even so continues still.*—I should have to give weight to the omission from the "Return" 737 of the effects of "shells" being demanded as well as the effects of "shot."—I should have to point to the negotiations and communications throughout 1851 and 1852 between the ruling Administration over Naval matters and what was then known as the "Shot Association,"—an association organized out of the larger and still-existing "Steamship Owners' Association," and composed of gentlemen deeply interested in the judgment pronounced against the use of ships of iron for Mail contracts, and the grounds of whose organization are expressed as follows:—

That the experiments made by order, as particularised in the Reports published in pursuance of an order of the House of Commons, No. 737, appear to have been insufficient to test conclusively this important question, for the following reasons, viz. :—That on the "Ruby," from the very slight nature of the plates and framework, and from the circumstance of no corresponding experiment having been made on a wooden vessel ; that on the target representing part of the side of the "Simoom," whether lined or unlined with wood, because no experiment was made at the same time and in the same manner on a target representing part of the side of a wooden vessel of similar size, in order to show the relative effects on iron and wooden vessels ; because no means were used to test the practicability of remedying the making of splinters by other means than wooden lining, nor of stopping shot-holes between wind and water in iron vessels, by inner plates or other contrivances, considered by competent persons to be practicable ; and because of

the inferior quality of the iron employed, the quality of the iron being a most important consideration in all such experiments, as the best iron would not be injured to the same extent as inferior iron by shot or shell.

And I should have to show how the demands of this Association for a fair open trial of iron against wood, shot for shot, shell for shell, hot shot for hot shot, when pressed so inconveniently as to make it necessary to victimize some wooden hulk against their large section of a "ship of iron," were at once gotten rid of by the removal of the "ban" complained of. I should have to show how in 1851 a direct "Motion," in connection with the objects of this Association, for "copies of any report made to the Board of Admiralty on or about the 13th of August and 11th of October, 1850, of experiments made for testing the merits of wood and iron-built ships for resisting the effects of shot *and shells*," was at once complied with by a "Return" which, when produced, was found to be "still born," and "ordered to lie on the table." All these and other historic data I should have to criticise and inflict on all in proof of what? That the experiments ordered in 1850 were never intended to overthrow those of 1846; and when such a discovery as would have had that effect did in reality occur, that it was equally an object to withhold it from publication as much as possible, lest indeed it should produce the open "overthrow" it certainly would have done, with all its awkward consequences.

I now, therefore, arrive at that portion of my Lecture which I have long looked forward to with a pleasure all the greater that I feel it will be one of equal relief to many others besides myself. I believe I have faithfully adhered to my self-imposed interdict against the mention of all names; but I feel nevertheless as conscious as any who may hear, or may read these lectures, that, in prosecuting with what I feel to be no more than strict and necessary faithfulness the investigation of a subject truly described as of "immense importance," it has been impossible for me to avoid presenting views which at first appearance might seem as if calculated to occasion reflections upon individuals.

In respect to "experimental" transactions, I need scarcely say that they all, of necessity, and as in every case is expressly stated in the records of them, emanated, not from those who executed them but from the orders of Superior Authority; and such orders, I again need scarcely say, are wont to be obeyed, as I trust they ever will be, with a zeal which regards it as a duty to adopt the very sense, in which what is required, is expected to be done, even if the judgment of the doer of it dissent from the merits of the requirement itself. I, therefore, claim that, in dealing as I have done with all such "transactions," as set forth in published records, I may be considered,—as also I have faithfully made myself to feel,—as not even to have known the names of the parties to them.

I just notice the purchase and employment of the two iron gunboats during the Russian war to observe that here we have actual proof of the recognition of the merits of iron for ships of war, on a small scale certainly, but still the principle was thereby fully admitted.

But I at once bring the most undeniable proof of where all responsibility for our position lies, by reference to transactions of the present day, and in the identical matter itself of "Iron-cased Ships." I will beg you to notice that the date of the letter I now read is that of the 15th

November, 1855, and the letter itself was addressed, as was due, to that "Department" whose special duties the subject of it concerned.

November 15th, 1855. This model and drawing show the internal arrangements by which the greatest strength is to be produced. They were designed by me for the construction of a shot-proof corvette. You are aware that from the beginning I have been a believer in the shot-proof quality of vessels made of iron plates of great thickness. About five years ago the eminent steam-ship builder of America, Mr. R. L. Stevens, communicated to me the result of a long series of experiments made at the expense of the United States government by himself, the chief practical result of which was, that iron plates of 5 inches thickness were absolutely impenetrable to the heaviest shot fired by the longest guns in the service, the heaviest charge of powder, and the shortest distance.

The model I submit shows the manner in which I propose to build a shot-proof corvette which would possess all the qualities of our present steam corvette, but would be of larger size and armament, and of perfect impenetrability. When I first made this design and model it was my intention to have taken out a patent for such construction applicable to war-vessels in general, but, as a patent involves publication, of which other countries would be able at once to avail themselves, I thought it better to keep my secret, and submit the matter in proper time in confidence to our own Admiralty, and which, accordingly, I now beg leave to do. *I beg at the same time to express my conviction from what I have reason to know, that if such vessels be not built by us they will speedily be built in other countries.*

Prophetic words truly, and it had been well with us had they been received.

But what became of this letter and the accompanying model and design? They were laid by. Where? In the "Hades" of the "Department." Why? Because it was of no use to present them. How long were they so laid by? Three entire years. Did the Designer ever inquire after them during that time, or endeavour to procure a presentation of his design? Frequently. And with what success? Always with the same answer, that it would do more harm than good to present them before the right time. Did the right time ever come? Yes; on the 10th of December, 1858, official correspondence took place on the subject, after personal interviews of a favourable nature, with high authority, and the project was then entertained. Did anything grow out of it? The "Warrior," the "Black Prince," and the whole British-born iron family, are the direct progeny of this official correspondence of December 1858, and therefore might have been of that of November 1855.

I claim to have now shown you, as I at first undertook, that the question of "Iron-cased Ships" was so mixed up with that of "Ships of Iron," that no intelligible separation could with truth be made in their history, I have shown you that in 1845 the Woolwich experiments gave results, the prosecution of which *might* then have led to "Iron-cased Ships." That the experiments of 1849, 1851 *must* have produced "Iron-cased Ships," had they not been controlled within that vicious circle of too thin and too thick, by which alone the pre-condemnation of iron altogether, could be and has been maintained. And I have shown that which is tantamount to their actual rejection, at least two years before "La Gloire" was begun.

I say, then, that from the summer of 1846 to the present day, England, in this great question of iron or wood for the national Fleet, has suffered one long, persistent, and grievous wrong. Years will not right it. Millions will not pay for it.

THE CHAIRMAN.—The Council are of opinion that it is desirable to confine the discussion to the subject-matter of Iron Ships versus Wooden Ships, and not to go on to the question of iron-plating, as Captain Halsted has not entered into that yet. It is desirable that in the discussion one on each side shall speak alternately.

CAPTAIN SULLIVAN, R.N.—With respect to the "Harpy" and "Lizard," mentioned by Captain Halsted, the reason I venture to make some remarks upon them is because I myself gave those two vessels the directions for passing that very place where these accidents happened. In going down past it just before, in a small sailing vessel, we succeeded in passing close under the battery, without a shot striking us. We went close under the muzzles of the guns, and I advised these two iron vessels to do the same. To quote the "Harpy" as an iron vessel fitted for war, it would be just as reasonable to quote my little tender-vessel that was not struck by a shot; because the "Harpy" went in so close under the cliff that every shot from the battery passed over her, though after she passed, and they got a gun to bear in a raking direction, one shot struck the Commander's arm. The only shot quoted by Captain Halsted to prove her fitness for war, is one that must have been fired in an oblique direction, because it went through two of the paddle-floats, and therefore it could not have been a direct shot. Her case does not apply in the least. The "Nemesis" case does not apply in the least to the question, as only one shot struck her. But the "Lizard" is a case so decidedly applicable, that up to the time of reading this statement of Captain Halsted I had always supposed it, as I believe all present had supposed it, to be conclusive against thin iron vessels as fitted for the purposes of war. She had only to pass five eighteen-pounders. There was a tide of three or four knots against her; she had nothing in tow. She could not have been long under the fire of these guns, because they were so confined in their training by banks of clay it was with very great difficulty, with the vessel passing even at the short distance she did, that they could get more than a couple of guns to bear whilst she went past; yet the damage done to her was so great, that before she had passed she had three feet water in the hold. I did not see her, but those who wrote to me described her as having proved the utter unfitness of iron vessels to be trusted within reach of shot. The men and officers were sent below. A shot struck one of the ribs in the gun-room. I believe the shot broke up against it: at all events the splinters the iron shot made were so bad, that one shot killed one officer and two men. Some round shot passed clean through and struck the opposite side; but I understood that her principal danger from sinking was caused by the fire being from a height downwards, driving out the plates under water. I have no doubt from all that occurred, that had she been a few minutes even under fire, she must have sunk before she could pass. All those who saw her gave such a very decided opinion, that it at once settled the question that these vessels were utterly unfit for war. To show how much damage she received, compared with wooden vessels, I may mention that a few days before, I met a wooden vessel, the "Alecto" of 700 tons, with three heavy schooners in tow full of troops. Just after I passed this place, she took these schooners past. She was so long under fire, in consequence of not being able to tow the three vessels round the point, that she got a great many shots in her hull. At last she stuck opposite one gun—the last gun; and that gun kept throwing down shot after shot—eighteen-pounder shot—at the pivot-gun that was on her forecastle, till it was knocked over by a shot from the pivot-gun. Yet, with all these shots, that vessel had not one man killed or wounded.* It was astonishing from the way in which the steamers passed, from the crew being scattered, and the comparative size of the deck, that there was no serious damage. The only case in which there was any serious damage in proportion to the fire was in the case of this iron vessel. One wooden vessel, the "Dolphin," had forty-six shots in her hull, principally 32 and 42 pounders. She had one-third of her crew cut down entirely by the plumping of round shot. She had her wounded laid on the deck just above the water-line, so that the shot passed over where the wounded lay. Some of the operating men were killed, but the wounded escaped, from being under the line of fire. Can any one doubt but that the wounded would have been all destroyed, had there been splinters of iron? I have not the slightest doubt of it. To bring the case of the "Lizard" forward as a proof of what an iron vessel can stand, is really contrary to the opinion of every person who was present and saw it. Then again with respect to these very experiments, I never heard of them till Captain Halsted read them; but the experiments seem to me to justify the report which was come to. We read of the shot splitting the iron into fragments, and driving them across the deck like a charge of grape. When

* We presume owing to the absence of iron splinters.—ED.

the experiments on wood were made the shot struck stancheons and caused many splinters; but those stancheons would have been in the rear of the men working at the sides. We did not hear of any such destructive splinters except from the opposite side and mid-ship part of the ship; yet these iron shot would, breaking up in passing through the side of an iron vessel, begin to spread the moment they passed through, and mow down the men just the same as if a charge of grape were driven through the hull. Therefore I think there cannot be anything in these experiments which can at all justify the opinion that the officers who made them did not give an honest report of the result of their experiments. With reference to the strength of these ships, which I think is included in this portion of the paper, I am leaving out the question of plating ships, because that is now a settled question—there is now no difference of opinion. The only question is whether those plates can be better placed on strong wooden ships or on iron ships. Up to 1850 certainly all the experiments had been made only on thin iron ships; the plating of them with shot-proof plates had not been thought of. Even the corvette which was proposed to be built in 1853, you will find, was after the floating batteries had been built—a year after the French Emperor had begun them. I think in November, 1855, those floating batteries had been tried against the forts at Kinburn. Therefore it at once explains why, when some one proposed the building of iron ships, it was merely adopting what had then been an experiment made principally with another form of ship. Then again when these ships were built in 1858, instead of party having anything to do with it, it seems to me they were built because it was found that France had got the start of us in building iron ships—and that anybody would have done the same whoever he was. But suppose the iron plates to be a costly thing, the only question then remains whether it is safe and right to put these expensive structures on an iron bottom. Letting bygones be bygones as to all these experiments, I think this is a most serious question, because we are going to a very great expense in putting very expensive structures on a bottom that I for one believe to be decidedly unsafe and unfit for the purpose. I have a strong opinion even with regard to iron vessels. I allow that, for sailing vessels, where they are not carrying passengers, and not very likely to be wrecked, where they gain in stowage, and are somewhat cheaper, it may be very desirable; but, after the results we have had of the wrecks of iron ships, after the numerous cases I have had before me during the last four years of inquiries into the loss of iron ships, my conviction is, that it is not safe to entrust the lives of men in any numbers in ordinary iron ships if there is a question of taking ground. It may be said, this is an old obsolete prejudice in favour of wood—in my case it certainly is not. The conviction has been forced upon me more and more as I have gone into the inquiry into the causes of the wrecks of iron vessels. They are all very well at sea, but directly they strike rocks, they go like brown paper. Take the instance of the "Birkenhead" for one. Not long since there was the case of the "Royal Charter:" she broke her back across a little ridge of rocks, where the worst wooden steamer would have perhaps hogged and bent, yet have held together long enough to save her crew. Not long since the "India" was lost on the coast of Newfoundland. She was one of those fine new steamers built for the Canadian mails. She had a number of passengers. It was not a gale of wind, nor a heavy sea. She went on a ledge of rocks so level that the report states there were two and a half fathoms of water in the fore-chains, amidships, and abaft; therefore she was nearly on a level bed. Can anyone suppose that a good wooden ship would not have stood a little grinding before she broke up? And any man of war would have ground there for days and days before she came to any serious mischief. This ship working on this ledge in a very few minutes broke in two in the centre. The two parts fell in opposite directions; and, before the boats could be got down, seventeen of the passengers and crew were drowned in these few minutes. Now there is not a wooden merchant steamer in the world that would have done that, much less a solid man-of-war steamer. Then again in the case of the "Birkenhead" she ripped up by trying to back astern. Not long before there had been an old paddle-wheel steamer, one of our old sloop steamers, on shore on a rock near the same position in a much heavier sea. As she lifted and bumped she was backed off by her engines, and, not having an iron bottom, they were able to keep her floating along the coast till they found a safe place to beach her and save the lives of the crew. Had she been in the "Birkenhead's" place she would certainly not only have saved them, but probably have come of with little serious damage. I could instance the case of the "Pique." We know she was aground twenty-four hours in a heavy sea on the rocks of Belle Isle, and yet she came home across the Atlantic with three-sixths of her timbers ground away. Suppose the strongest iron ship ever built, if she had a double skin with three feet between them, even the three-feet soles of the "Great Eastern," will any man believe that those blows which ground away three-sixths of a wooden bottom would not

have gone clean through both skins and everything of the iron ships? On one occasion in the Baltic one of our old forty-gun ships that had been built for a steamer, and had all the heavy engines and boilers of a three-hundred-horse-power steamer in her, which made her strike more heavily, stood in for the land. She found herself in a wrong position. She stood off, not knowing exactly where she was. There were dangerous rocks outside. Those rocks had a fathom less water than she drew and she ran right on the centre of them. The captain was a good masterly hand, and he knew the only chance was to take advantage of the lift of the heavy gale, for she was under a close-reefed topsail, and force her over this patch of rock, a mile in extent. At every lift he pressed on sail, which carried her forward, and at last got her off. The blows on the bottom were so heavy that her top deck bulged up at every blow. That vessel went over those rocks, stayed out, and did her work to the end of the season in the Baltic. Can anybody suppose that the "Warrior" under those circumstances, with her tremendous weight of 7,000 tons, going down on her bottom, would have stood that for ten minutes? Her ribs would have been broken; and, if she did not drown all hands, the 300,000*l.* she cost would have been lost. Now it is a serious question, the employment of these ships in time of war. They are all very well to run across the Atlantic, not entering ports any time after dark; but when you come to a time of war, these ships must keep on an enemy's coast night and day. A man knows if he has a wooden ship under him, and she hits a rock that she will get no great damage: but if he has one of these iron ships under him, however anxious he may be to keep in and risk a few rocks, I do not think that there is any man in the service who would dare do it, if he has at all the conviction that I have as to the unsafety of iron ships; because he would know that, not only would the ship be a total loss, but in all probability he would lose the lives of the whole crew. When these iron vessels do fill they settle down. When sunk they may remain, owing to their weight, more steadily on the bottom than a wooden ship; but they settle down so rapidly that the sea breaks over them in such a way that no one could live on their decks, and the chance of getting them off would be hopeless. There is one case, often quoted by the advocates of iron-cased ships, that of the Tyne. She went into comparatively smooth water on the coast, to the east of Portland. She struck, not very heavily at first, and she answered her helm and kept getting off till she had come round from about E. N. E. She was steering off to S. E., and her head was nearly E. There are many of my friends here who have been in ships in that position, and they know that as long as a ship is moving, however hard the strikes, she will come off, and there will be very little damage done. In this case there was no shallow or water outside, but the moment she struck she drove in her bottom plates; though she was coming round and answering her helm, she was settling down from the rapid filling of one compartment; and where she was in a position that a wooden ship would have come off, she would not move. That ship lay there. They had to build off the compartment where the damage took place, and then with immense lifting power to lift her, with the additional weight of the water in this compartment. When the "Sphinx" went on shore on the Isle of Wight, she beat over rocks with much less water than she drew. As far as I recollect, she beat over at first a reef of rocks. She then went into deep water, and was brought up by an inner reef. That vessel lay there exposed to the whole swell of the Channel for months. The only difficulty was to take her out over this reef. She came off after all these months of grinding, having been kept clear by her own pumps. Again, the "Great Britain" went on shore on a sandy beach, with one lump of rock there. She had no rock outside, and as she settled down on the sandy beach the rock went through her bottom—she settled down over it, there being a great weight of iron with the water in her. With breakwaters outside her she managed to lay there for some months. But they had to lift up and repair her bottom, and get this rock out of the way before they could think of getting her off. The "Gorgon" beat over a reef of rocks nearly half a mile from where she grounded. She beat on this reef of rocks with much less water than she drew, in a heavy sea, and she tore off her bottom, but she made no water. The consequence was she went over the reef in safety and drove up on the beach, and lay there as long as the "Great Eastern" did. But she was got off, and was so uninjured that she went and did her work for a twelvemonth on her station, and then came home. But put an iron ship in position just as the "Gorgon" was; in beating over that reef, if she did not settle on it, is quite certain the rocks would have driven some of the compartments in; and in passing in she would have sunk before she got in, and there settled. I feel that as a certainty. Any one who thinks of the difference in the cases, and thinks of the way in which that rock went through the bottom of the "Great Britain" would know that if she had beat

on a rock of less water than she herself drew, as the "Gorgon" did, she would never have reached the beach. There is scarcely an instance of a wooden man-of-war being lost from getting on shore; the cases are so few in which they are not got off again, that there are only a few exceptions. But when iron ships once strike on the rocks, the exception is when they are recovered. Not only is my feeling strong about placing these expensive structures on iron bottoms, but if the responsibility rested with me I should feel it a positive duty not to send out even troops, emigrants, or any men whose lives were at stake in one of these iron-built merchant ships. I allow that there are some advantages in combining the wood and iron in these iron-bottomed ships. But we must recollect another thing, viz., that we have to get over the question of keeping the bottoms clean. Even at the Society of Arts, one of the iron-ship builders stated it was necessary to find some plan of sheathing them with wood outside and coppering them. I had it from the same officer whom I have quoted, that the "Himalaya," if her bottom is not cleaned every year, would have her speed considerably reduced.

Mr. SAMUDA.—Captain Sullivan has thought proper to refer to a subject on which I had no intention of making any observations this evening, but to which I now think it necessary to refer for a few minutes before I come to Captain Halsted's paper. I scarcely imagined that at the present time it would be necessary to rise in defence of the question, whether it was moderately safe, or whether any sane person would take upon himself the responsibility of allowing valuable lives to be trusted in iron ships performing ordinary voyages? That such a question should be raised by a gentleman who holds the position in the Board of Trade which Captain Sullivan does, is one of the most extraordinary things it has been my good fortune or misfortune to listen to. I will only just put it in one practical point of view, and then I will dismiss that part of the subject altogether. I will first of all mention this circumstance, that while Lloyds, who ought to be pretty good judges of what is the ordinary value of ships' risks, charge something like from six to eight guineas a-year for insuring the ordinary wooden craft, which, according to Captain Sullivan, perform all these voyages with such admirable superiority, the Peninsula Company perform the office of their own insurers; and I can speak from information received from the managing directors, when I tell you that from twenty years' experience their insurance account has not yielded them a charge of two per cent. upon the cost of their shipping—their fleet being entirely an iron fleet. I will only add further, that when it is attempted to disparage a mercantile marine of universal application throughout the world, by quoting such cases as the "Birkenhead" and the "Royal Charter," I think Captain Sullivan ought to have explained how very exceptional those cases are from those which might reasonably be looked for under an ordinary state of good and efficient and well-built vessels. The "Birkenhead" was a vessel built very many years ago. The destruction—the absolute destruction of the "Birkenhead" was due, to what? To an iron vessel—I will admit improperly constructed—not being able to possess herself of a means of security, which a wooden ship has not yet been able to possess herself of at all, of bulk-head divisions, to separate entirely one part of the ship from the other. These bulk-heads when improperly placed in ships, or placed without the amount of experience which may reasonably supposed to have been obtained since the building of that ship, are, I say, a source of weakness to a ship on the occasion of her taking the ground, though they are a source of great security to her on the occasion of one portion of the ship being perforated. I should not say they are a source of weakness, but I should say the way in which they were placed in the "Birkenhead" was a result of weakness. I believe the same observation applies to the "Charter," I am not at all defending the "Charter:" I do not want to say a single word about the "Charter." But when that is quoted as an instance of the inferiority of iron ships, I will just inform Captain Sullivan of what has taken place in three or four cases with iron ships that have come under my own knowledge. In the first place, there was a vessel I built myself, which, after she had been at sea for two or three years, got on shore in the entrance to Neath Roads. I was telegraphed for to send down men to see what possibly could be done to save this vessel, her destruction being considered imminent. She was loaded with 700 tons of iron ore, a full cargo, and she had taken the ground in such a position as to leave fifty feet of her after end unprotected, that is to say wholly unsupported. The weather was extremely bad, so bad that there was no possibility of going to the vessel and lightening her; and the tides were taking off so that she could not be floated. The only answer I was able to telegraph back was, "I can do you no good; let her take her chance." That vessel lay upon that shore for seven days, with two or three days of most severe gale. It was so severe that no craft could go to her to lighten her. At the

end of the third or fourth day she was lightened sufficiently to float, when the returning tides of seven days took place. I had sent down in the meantime a foreman and two or three men, with instructions to get as many more as was necessary. The whole cost of the repairs of that ship was 12*l*. The first thing after she floated her own engines were put to work, and she steamed forty miles before she could get on to a gridiron in order that it might be seen what was the matter with her. A few plates were strained; they were caulked, and the vessel went on her service and worked for two years after that. Now, is it not too much for any gentleman to quote iron ships as being unsafe for people to be in, when so many know of what they may be made, and when we all know that the best services performed under the sanction of Government and by many of the first commercial countries in the world, are done—not partially—but wholly with iron ships? I am really surprised to hear any one make assertions to the contrary. (Hear, hear). The destruction of the "Paramatta" which took place the other day, and which must have come under Captain Sullivan's notice, was about as good evidence as any one could wish of the enormous strength that could be given to a good iron ship. That ship was placed in a position on the rock from which it was impossible to release her, and she remained there for months. Not more than a fortnight ago the observation was made to me by one of the managing directors, "I believe a large portion of her remains there still." She remained there undestroyed for months and months during the heaviest weather. It was perfectly impossible from the position in which she took the rocks to get her off again. That was the description given of her to me, and I believe it was perfectly true.

Then we have got the fact and the knowledge, in spite of the experience of the last speaker, that the Peninsular Company's ship, the "Northern," went on a rock in precisely that position which was described by Captain Sullivan as certain to be fatal to an iron ship; and yet she is as good a ship as they have in their fleet at the present day. Therefore, I think it is wasting time, after the examples, not only that I have put, but the world-wide and notorious examples that everybody has within his own observation, to attempt to decry iron ships as being useless, when they are found to be as useful and practical, if properly made, and as strong as any structures that ever floated on the waters.

Now, to refer to the matter which is more immediately the subject of this evening's debate, which all of us and the country generally take an enormous degree of interest in, I think it necessary to say that to deal with the mere question of an iron ship by speaking simply of a ship constructed of iron plates in the way in which we construct merchant ships, would be to throw ourselves a quarter of a century back; in fact, would not be raising any issue which would be useful for the practical purpose of the question of advancing our navy. To make this question useful, you must deal with the question of what profit, what advantage, we should have by constructing the vessels protected in the way, or somewhat in the way, in which it is intended to protect them at the present moment—whether these vessels be of wood, or whether they be of iron. I do not think the observations Captain Halsted has made with reference to the ⅝ plate shivering shot and shell to pieces would induce any person (if the mere question required to be resolved by this answer had been, "Are these the only ships—the only mode of construction—which you propose to adopt?") to come to the conclusion that vessels with sides of ⅝ plating, or something approaching to it, were the right things suitable for vessels of war. We have got a great many stages beyond that. I think we have got completely into the right direction by taking iron hulls, and protecting those hulls so as to make them shot-proof. Now, there are certain points which appear to me to be most essential—in fact, fundamental elements in this question. Granted that a vessel cased in iron plates is a right thing to meet the artillery of the present day, what are the conditions—and that I think is the most important thing of all to start with—what are the conditions which are indispensable to enable that vessel successfully to be a ship of war? The first condition which I think absolutely indispensable is, that it should have at least equal speed with, and that it would be far better if it had greater speed than, any ship it is likely to contend with. That I believe to be essential because, shutting out altogether the question of speed, if you protect these vessels as well as the weight you can afford to carry upon them will allow you to protect them, you run a great risk, with the means at your disposal to make a successful result, of destroying that result, and thereby throw yourselves back some twenty or thirty years. Speed being the first point essential in all iron ships of war to make them successful, the next is to protect them entirely from one end to the other. If we must have the fastest ship, and must have a ship wholly protected, the question then arises, how are we to do that? I will not go the length of saying it is impossible to do that on a wooden hull; but I do go the

length of saying, it does involve so large a vessel, and so much strength of structure, to enable that ship to be practically useful, that I really believe you are shut out from the possibility of any other hull to build on than an iron hull. Now, the "Warrior," and vessels of the "Warrior" class, combine in a great degree the requisites which I have laid down as the necessary qualities to start with. The "Warrior," I believe, will be a faster vessel than any vessel whatever in our own navy, or in any other navy in the world. But, then, the "Warrior" does not possess the second requisite, that of being entirely protected from end to end; it is only protected in the centre. But the question of the protection of a vessel is after all what I may term a ship-builder's question. It is not a question connected with the gentlemen of the navy, except in one respect, that is to say, they would all of them be disposed gladly to accept it if the thing could be done, but they imagine probably that the thing cannot be done. Now I believe the thing can be done. I have no doubt in my own mind that a vessel of the size of the "Warrior" may be successfully covered from end to end with an armour as perfect as that which she has on, nay more perfect, and yet draw no more water, or rather less than she does at present—in other words, be no heavier, for it is a mere question of weight. With reference to those reports which Captain Halsted has brought forward, of the firing on the two targets, one of a simple plate, and the other of a ½th plate, backed with a great quantity of wood, though they they really are not very useful for present purposes in the present day, contrary to the conclusion which Captain Sullivan came to, they seem to me to convey the same result. In both cases they appear to have thrown a large quantity of splinters, and to have made holes in the side of the plating nearly identical.

Captain Halsted.—I was comparing those with the wooden ships, not comparing them with each other.

Mr. Samuda.—I am comparing them with each other—the two sides, different portions of the same ship. It appeared to me there was a very slight difference in them. The experiments I have made myself corroborate this view. I have fired at iron plates, and then at plates with wood at the back of them, and I can find no difference in the size of the hole, nor do I find the slightest difference in the fracture made by the bullet, whether the wood is behind the iron plate or not. And, if you reason upon the thing, I think you will find it is reasonable to come to the conclusion that there should not be a difference. Now what is the meaning of "backing?" "Backing" means support. If you take an iron plate and put behind it something, the object of which shall be, if this plate gives when it is pressed with a great amount of force, to enable it to resist the pressure, it follows that that which is behind it will come to its assistance. Now, if I put two iron plates accurately planed one against the other, it is perfectly clear that the particles of the back plate would be in as close contact with each other as the particles of the front plate, so that the particles of the front plate, being pressed against the particles of the back plate would receive some assistance from them; and the assistance would probably be this: if the front plate were 2 inches thick, and could give a resistance, without the back plate, equal to a force which we will represent by 4—the square of the thickness—the back plate would come to its assistance with another power of 4, and the two together would give resistance equal to 8; but, if I take away this back plate and put on at the back of the front plate a substance which would yield to a much greater extent, from its particles not being in such close connection with each other, than the front plate could do before it broke, it stands to reason that that would give a very modified, if any, assistance to the front plate. That is the case with a piece of wood. A piece of wood will bear a squeezing up, a pressing before it reaches the ultimate point of breaking; it so moves away that a 4½-inch plate would have to be distorted out of its form to a considerable extent before it could receive assistance from this piece of wood. That would necessarily cause it to break; consequently, it would receive no assistance whatever from this piece of wood. The wood, it is true, would be a second defence, it would prevent the shot going into the ship, but it would afford no assistance to the iron in preventing it from breaking. If instead of this piece of wood you put a piece of metal, whose particles are equally in close contact with each other as the particles of the iron plate itself, you would receive an assistance equal to doubling or repeating over again the amount of resistance of the iron plate itself, that is to say, if the front iron plate had a resistance of 4, the two together would give a resistance of 8; but if, instead of putting two, one as a support to the other, you made the whole in one plate of four inches thick, instead of a resistance of 8 you would have a resistance of 16, because you would have a resistance equal to the square of the depth of 4 inches, which would be 16. Therefore, by carrying the same weight on your ship's sides, you would get exactly twice the amount of resistance you would have with the iron backing; and that I have shown is much more effective than the wood backing.

If you follow out that principle, by substituting for all that large amount of useless wood a plate in weight equal to the wood, then, with that and a 4½ inch plate you would get a 6-inch plate. Incorporating that 6-inch plate into the top side of your ship, you first of all get an armour which will give you nearly double the amount of resisting power that you get in the present "Warrior." But you get a great deal more than that; you so reduce the weight by doing away with all the top side of the ship to which you hang all this armour, that instead of making the top sides of your ship weak you make them extra strong, by the top sides of the ship being both constructed of, as well as coated with, armour. You would be able to cover the vessel from stem to stern with a plate 6 inches thick and 5 feet below the water, and have 270 tons less weight, and your vessel would float 6 inches higher than the "Warrior" does at present, yet covered from end to end with armour. Now I ask, when such things can be done on an iron ship, and when any one analyses the way in which an iron ship is put together and the way in which a wooden ship is put together, can there be a doubt as to the comparative strength of the two structures, or a belief that iron structures will be done away with? Mark for one moment what necessarily takes place. In putting an iron ship together, if the thing is well put together, you really produce exactly the same result as if you had formed the entire structure of one plate of iron from end to end. You do not do that with a wooden ship at all. Every seam of the iron ship is rivetted and fastened together; and if properly done the strength of each seam is equal to that of the solid plate itself. Now in wooden ships the strength depends upon the strength of the fastenings which you put through the timbers. A very good plan when vessels are kept continually floating, and up to the time of iron ships the best plan you could get. But when we have arrived at a point where we are able to make iron vessels so strong, that we might make them, if necessary, equal to stand a pressure of fifty or sixty pounds to the square inch—for that is really the strength we might apply to iron vessels if properly put together—and where wooden vessels would not stand a fourth of that pressure without yielding in every direction, it is a little beyond the mark to talk of iron ships being unfitted to convey valuable lives. I would mention another instance with regard to iron vessels which you cannot hope to get with regard to wood. I recollect a vessel going down the river one day in a fog. She came back the next day to my works to be repaired, cut down by another steamer having run into her to four feet below the water's edge. The engines brought her back to the works. No part of her cargo was damaged. The accident was confined to the compartment which was struck—the bow compartment. That was full of water up to the water-line; but beyond that there was no water in any other part of the ship. Surely, these are advantages which are of no small amount. With regard to the vessel I told you of, the Paramatta, I believe at the time and for a long time afterwards, during which they hoped to save her, they got the water completely excluded from every compartment except the compartment in which the rocks had penetrated her bottom. I do not speak with certainty as to whether that was so in the first place, or whether that was the result of some additional security and help they gave to the bulk-heads afterwards. But, be that as it may, whether at first or afterwards, the bulk-heads in the ship enabled them to do this; and they did it so completely that for a long time the water flowed in and out only at that portion which was penetrated, and in no other part. I think the points we have got to deal with in this discussion resolve themselves very greatly, not so much into what was done some years ago, as into what has got to be done to complete our present doings with regard to these vessels. Though I have spoken thus strongly with regard to the observations and experiments which I have made, I would suggest, that the wisest course in this case would be merely to accept them as the result of so much observation, so much experiment, or so much speculation on the part of one who has had some opportunities of making some experiments and thinking a good deal upon the subject. I say, let experiments be tried. Let two or three targets, not of a small size, but of a very large size, be tried, having these different qualities of armour placed before them. I fancy the whole thing resolves itself into this. The great question, the great point of anxiety, will be to determine which is the best way, when we have got these iron hulls, of dealing with them—whether to put one description of armour upon them, or to put another description of armour upon them. All I hope and sincerely wish is, that the result of these deliberations and discussions here will be, to convince the Government that the wisest, and cheapest, and quickest course will be to get an elaborate set of experiments made on several descriptions of armour as from a reasonable consideration of the matter seem likely to produce a good result; and then to avail themselves of the assistance of such of their officers as may be likely to lead them to a correct conclusion as to which of these kinds of armour is the best.

Evening Meeting.

ADJOURNED DISCUSSION.

Wednesday, March 20th, 1861.

CAPTAIN E. G. FISHBOURNE, R.N. C.B. in the Chair.

Capt. STOPFORD, R.N.—Capt. Halsted on Monday night referred to the experiments that were made at Portsmouth in 1850, and said that great secrecy was observed in regard to them, and that he could not find out the different results till some years afterwards. I happen to have been at the College at Portsmouth when these experiments were made, and I, in common with every other officer at the college, was allowed to go on board the "Excellent" to see them. I made my own notes at the time, and this morning I looked at my note-book again; and I must say I found that everything which Capt. Halsted said he had discovered so many years afterwards was confirmed by the note which I made at the time—particularly with respect to Capt. Moorsom's shells, which broke in striking, and exploded. I find, I said, "the powder flew to leeward in a black cloud." I believe, as I have said, that every officer at the College might have gone on board. There was no secret made of it. The subject was discussed commonly among the collegians, and the target, after it was brought ashore, was put up in the factory, and I made a sketch of it; and I am sure, if Capt. Halsted had been there at the time, and had gone to the college mess, he might have heard the subject talked about like any other subject, and he might have discussed the whole of it with the port-wine class afterwards. In looking to-day at the plan I made of the target, I find there was one thing that he did not mention. I saw that a 24-pound shot fired from a boat diagonally, so as to strike the iron at an acute angle, took out a large strip, and made an oval or oblong hole. One hole was 13½ inches by 5½ inches. I have nothing more to say, than that I was not aware of any secrecy at the time; and I could have told Capt. Halsted the day after the experiment everything that was carried out, without, to my knowledge, infringing the orders of Capt. Chads, the captain of the "Excellent."

Capt. HALSTED.—With regard to Capt. Sullivan's statements in reference to the "Lizard" and the "Harpy," it is a matter of great surprise to me that I should be considered as illustrating the benefits and advantages of iron ships for the purposes of war. If I were to meet him here again, I should ask him to accept one of the printed copies of my first lecture, in which he will see that I refer to the most distinct evidence which exists in public documents, to show that those vessels were never intended for actual war—that they were expressly set off as not intended or built for actual war, but only for limited service with a limited armament, generally having reference to river duties upon the coast of Africa. During the river troubles which took place in South America, they were sent across there; and I believe I may take Capt. Sullivan's own evidence in confirmation of the manner in which they there did their work—especially the "Lizard." He says that he found her with so many feet of water in her hold; yet that vessel, six weeks afterwards, was engaged again, in a perfect state of repair, with the same batteries. He speaks also of the general impression which then obtained in that part of the world with respect to the unfitness of iron for ships of war, and speaks of it as something victorious, and so forth. I think that, in doing so, he merely exhibited a remnant of that same foundation error which existed when the first attempt to introduce iron into the Navy was made. People then really

and truly believed that, because a ship was made of iron, therefore an iron shot was bound to bow and respect her, and not do her any harm. It was in that sense especially that the grape-shot I referred to was sent home to show, as the record stands, that a grape-shot would go through a ⅞ plate of iron. We now know, in consequence of the experiments which are published in this Blue Book that I have had occasion to refer to so much, that a ⅞ plate is perfectly penetrable by grape-shot, at a distance of 200 yards, from a 32-pounder with a 6-pound charge. But, if he had looked again at the statements made in this first lecture, he would also have seen that, by data supplied in this very Blue Book, where the proportionate resistances of certain thicknesses of iron and of wood are gone into, as proved by a series of experiments, that those resistances appear to bear the same relative proportion as the difference of the specific gravity of the two materials—a proportion of 1 to 8. And therefore, upon that calculation, the "Harpy" and the "Lizard," with their ⅞ plates, to have had their equivalents in wood, would have represented a ship's side of a 3-inch planking; and Capt. Sullivan and all those who may have had experience in naval strife know perfectly well that wooden ships with 3-inch planking are not those which are practically considered as fit for the purposes of war. These vessels are not intended or expected to be. They are properly stated historically to have been a great number of tender-packets and small vessels, intended for limited service, and with limited armament. Such were both the "Lizard" and "Harpy"; but I maintain that, as far as their services went, they upheld most distinctly the objects and purposes which were had in view by the introduction of iron into our service in those days. It was not an increase of protection; it was to realize the advantages of iron instead of wood—all those material advantages which had been up to that time absolutely proved. And when iron was introduced for purposes of war, if there were no disability in the material beyond that presented by wood, then the object and purpose of those who introduced iron amongst us would have been fulfilled. It was never intended and never expected—there is the most direct proof that there was an absolute disclaimer of it—it was never intended or expected by anybody that the shot would pay more respect to a ship of iron than a ship of wood, in proportion to the power of resistance of the two materials; but that mistake did occur. I have done all I could to endeavour to remove it, and put the matter upon its own true basis. Then again Captain Sullivan brings forward a statement which he heard about the two men, two officers, having been killed in the gun-room by the fragments of either the rivets or plating. It would have been more satisfactory, I think, if he had said that there were records in the Admiralty or elsewhere which I had not quoted, and which went to prove what he stated. What I have stated here with respect to the circumstances regarding the killed and wounded, has not been either attributed or attributable by those present to anything connected with the peculiar material of which the ships were constructed. I have taken my statements from the actual records in the Admiralty. They know of no others. There is the whole correspondence perfect and complete. I have examined the killed and wounded lists, and there is not the slightest reference whatever to any single soul having been injured in any way from any peculiarity in the material of the ship; and therefore in meeting the position which I have taken upon the face of the Admiralty records, I think Captain Sullivan was bound to have stated from what records he got his contrary statement; otherwise I think that it is a question of *bonâ fide* record against mere opinion, or rather a mere opinion against a *bonâ fide* record, and there is no substance in it; and I would refer again to what I have already stated in my first lecture. The very grape-shop that was sent home was said to have killed the man's brother; but the man whose brother is said to have been killed applied to the Admiralty and had the grape-shot given to him, not because he ever heard it had killed his brother, but he said, "I have seen a report in the *Times* that the shot which was brought home in a particular ship and sent to the Admiralty did kill my brother." That is the whole authority for it. There is not a single word in the letter of the commander with reference to the sending home the grape-shop, which shows that it killed anybody, yet he gives a most accurate account of everything that the unhappy grape-shot did, and everything that came in its way, and forgets to say that it killed the man. Everybody knows with what ardour these things were questioned at the time, and there was an express order sent out to the "Harpy" and the "Lizard" to make a report of what injury was done to them, especially as regarded their material.

That report became the subject of discussion in a particular place which I will not and need not name. There is not a word in that discussion to say that a single person was wounded from any peculiarity in the material of the ship; but, even supposing that two men had been killed, and that two men had been wounded by a splinter, whether it were iron or whether it were wood, we have again only evidence of the same error, as if neither men nor officers had ever been killed by wooden splinters, and the only splinters that could kill men were those of iron! It only shows that one has to deal in a question of this sort with a very great amount of—I will not call it prejudice, but of prepossession, and that men have not taken the trouble to examine closely into the subject upon which they speak. With regard to the state she was in under water and so forth, I only mean to say that there we have a corroborative evidence of what is stated in Sir Howard Douglas's work, that they managed to plug all the shot-holes, and there she has been working ever since she has been with me, for the last three or four years up to January 1860, and is as sound as a roach at this moment. All her repairs were effected, and she was again in action with the very same batteries six weeks afterwards.

With regard to the question of the relative destruction of ships of iron and ships of wood when remaining on shore, Mr. Samuda in the first place answered my remarks, which would be more applicable upon a general view; but I am taking the question principally and almost entirely with reference to the Navy; but it is curious that Captain Sullivan, in speaking of the rapid destruction of the "Birkenhead," did make an allusion, I am aware, to the destruction of the unfortunate "Thunderbolt" very close upon the same locality. There was a pretty case of ripping in the case of the "Thunderbolt." The inspector of machinery, who was my great coadjutor at Sheerness all the time I was there, was the chief engineer of the "Thunderbolt," and upon his authority I can state, that so perfectly did the "Thunderbolt" rip herself up with the rock, that she ripped up one of her tanks inside. The rock entered the ship, and ripped up one of the tanks in the forehold, so that there was as tidy a little piece of ripping as could well be effected in the case of iron, and that was close to the same locality as that of the destruction of the "Birkenhead."

Now I have done with Captain Sullivan, and I address myself to the remarks which were made by Mr. Samuda. I perfectly agree with Mr. Samuda about his question of wood as a backing to plates. If we could by possibility get rid of it, it would be a great blessing, and I state this plain and simple fact and circumstance, as having forced itself upon my own mind, and I formed a strong impression from what I have witnessed myself, and which I mentioned the other day at the Institution of Naval Architects. The "Terror" was placed at my disposal during the greater portion, I may say, of the winter of 1856 and 1857, for the purpose of carrying on a series of steerage experiments outside of Sheerness to the north, and there we had to lay frequently, in very nasty bad weather.

I wanted to complete the experiments, and did not want to come into harbour. But I had occasion to notice, as I was looking over the side when we were rolling about at anchor, the quantity of water that got in between the plates as the ship rolled, it was one continuous water-spout along the whole length of the ship, the water was spouting out at every joint. Of course I could see from that circumstance that there was an enormous destruction of timber going on, and I am therefore perfectly alive to the value of doing away with the timbering as a backing to plates, if it can possibly be done, because I think that timber in that position is placed under very unfavourable circumstances; it is jammed to death between the two pieces of iron; there is the thick iron outside, the four-inch iron armour plate, and inside again there is the five-inch plating of the actual ship. I referred in my lecture of Monday to the two drawings before you. I do not say the number of the shots are equal, but if anybody will look at them, he will see that they are fired at equal thicknesses of plate in the one case, without any timber-backing behind, and in the other case with the timber backing—the one being, as it were, a partial representation of the real side of the "Simoom," that is, the one without the timbering, and described in the Report—she being described as a frigate, and the other having the real and substantial filling and planking over that of the "Simoom" herself,—and I think any person who looks at the drawing will see that the one set of holes are very irregular and broken. I do not mean to say that there is nothing approaching to an irregular hole in the case of the unbacked plate, but as a rule there is a marked difference between the one and the other, and a

critical examination of the details and the effects of the shot in the two cases will support that view. I shall have in the next lecture upon that point to bring in illustration a very peculiar case, showing absolutely and practically as perfect a comparative effect upon the same plates with the same guns, at the same distance with the timber behind the plates in the one case, and the timber before the plates in the other, and therefore I will not now go into that question of the backing and of the wood. The only remark which I will make with regard to it is this, that we cannot wait for those experiments which may enable us to ascertain whether we can, or under what form or conditions we can, do away with backing. I think every effort should be made to do away with it. The two materials, the one of them perishable, and the other very indestructible, are an unnatural alliance, as it were, and all means ought to be sought to do away with it; but we have not the means at present, and we do not how to do it. No doubt, in every ascertained case of firing at plates, the resistances of the shots, as represented in those drawings, are every one of them just in proportion to the substance and strength of the timber behind the plates. Now Mr. Samuda seemed to think that any question with regard to ½ plates, and so forth, was quite out of the question, and that all these experiments about the "Simoom's" ½ plates had nothing to do with the present question. I think I may use upon that point this sort of illustration. I will assume that he had, as he tendered for the contract for the building of the "Warrior," or any of the "Warrior's" sisters, the "Defence," or the "Black Prince," or the "Resistance," or the other three, which, as far as I am aware of at this moment, are nameless, what would his first work have been to do? Would he have had anything to do with iron plates and armour plates at all? His first operation would have been to have built a six thousand ton "Simoom" out of ½ plates, and nothing more—a ship proportionately stronger than the "Simoom," inasmuch as a six thousand ton ship would be stronger than a two thousand ton ship, and inasmuch as she would be intended to carry a coat of armour, which the "Simoom" was not intended to do; he would have had to provide the means of clapping the armour upon her, but his bonâ fide ship would have been a ship of iron, and not an iron-cased ship, and she would not have become an iron-cased ship until her iron casing was put upon her. Now, Gentlemen, permit me to say that I am conscious to some extent that I have caused disappointment to many in giving the name that I have to my lectures, and in not speaking of ships of iron and iron-cased ships; but will anybody be good enough to make the distinction for me, for I am not at all able to make it myself. Every one of these ships are "Simooms," ships built of ½ plates of iron; and after each ship has been built in its own perfect form, there is then put, as I may say, upon this man-at-arms, a padding, not of chamois leather, such as our forefathers used before they put their armour upon them when they went to fight, but a padding of timber 18 inches in thickness, and upon that the man's armour is put. These are, as you may say, real aquatic men-at-arms, and Mr. Samuda wants me only to deal with the man's armour, and to leave out the man altogether. I beg to say that, to the best of my knowledge and belief, the more natural course is first of all to speak of the man, and then to speak of his armour. That is what I am doing. I speak in the presence of Captain Ford and Mr. Rolt, who can correct me if I am wrong; but I believe upon every point I am substantially right. That is what we are doing. And now with reference to what has been said, or what it may be supposed has been said upon another point, that all these questions of firing at iron plates ten or eleven years ago had no reference to the question of what we are doing at the present moment. Every one of those ships, or the whole of the four first of them, and, as I believe, it is now stated—what alterations may take place I cannot say—the fifth ship that is to be the third sister to the "Warrior," and the "Black Prince," and that is to be built at Chatham, will go into action with not so much means of resistance against shot and shell as the targets of the "Simoom" that were fired at in 1850, and condemned as perfectly unfit for all the purposes of war. Every one of those ships will go into action with plates not so well calculated to resist shot and shell as those were over one-half of their whole length. They are only semi-men-at-arms now. The "Simoom," which is underneath, is only armed with a coat-of-mail over one-half of the man-at-arms' body. The central half of the ship is perfectly protected; there the man has got the armour; but the foremost quarter and the aftermost quarter have absolutely those very condemned ½ plates, and moreover there is not the timber backing. The holes that are to be made by shot and shell in the fore part and in the after part of those ships are there faithfully

portrayed in the drawing in the thing I have specified as No. 1 target, saving this, that it is possible of course, and perhaps likely, that the material of iron plating is better than it was ten years ago but with that exception, there is the very same; and yet for want of a little examination people conceive that I have been treating here of iron-cased ships, and I had no business to speak of the bonâ fide ships themselves, but only of their armour. Every one of those ships is a condemned "Simoom." In the record of those experiments there are words by which iron of $\frac{4}{5}$ inch in thickness is condemned as perfectly unfit for the purposes of war, and those plates are going to be dragged into action in each of those ships—I am not speaking of the two last, because they will carry their armour throughout their whole bodies. I think, therefore, that my observations upon this matter were not quite open to the remarks of Mr. Samuda, and that if he had received the contract he tendered for, he would have found that the most serious part of his work was actually the building with the $\frac{4}{5}$ plates of iron. The armour itself he might or might not have been—he would not in all probability have been —the factor of, and he would have been told how to fit it on, so that his talent and ability as an iron-ship builder would have been called forth upon the construction of a six thousand ton "Simoom" of only $\frac{4}{5}$ plate, but with thicker timbering, or at least stouter framing. There is another point upon which I would make some observations. I think the contents of my lecture, which I gave you the other day, if I have faithfully copied the documents which I put before you, go to this effect,—that most undoubtedly at Sebastopol and at Sinope, the destruction of the Turkish frigates in the one case, and our own vessels being driven off from the fortifications at Sebastopol in the other —I hope I do not offend the dignity of any person who was present; I had not the honour of being there myself; but when I say "driven off," I mean, which left the field with the fortification untouched—was the result in every case of the shells; and nothing could have been more perfect and complete for my purpose than that Sir Howard Douglas should have gone into the whole question of shells to ascertain and show what were the effects of shells in determining the fight, and to determine the relative positions with reference to the ultimate object of destroying one or the other of the ships at Sebastopol. I am quite aware that he adduces this for the purpose of showing the superiority of time-fused shells over concussion shells; but, however be it so, it was the effect of shells of both descriptions, which undoubtedly, according to the statements given by himself, inflicted the most serious loss upon our ships there, and actually caused the destruction of the Sinope ships. Well, as I mentioned in my lecture, those shells were explosive shells, and had the assistance of Martin's incendiary shells; and now, I ask, what reason is there for supposing that any ship whatever of wood—a line-of-battle ship, a sloop, or a frigate, or a ship of any kind—can by possibility stand the fire of explosive and incendiary shells?

I am merely expressing my own strong conviction; but I say that, if we continue to send forth our ships without that plating which is known will defend them from shells, I faithfully believe there will be a very wanton sacrifice of life in the case of every ship that is subjected to them, and that is capable of being protected against them. Therefore, with regard to Mr. Samuda's remarks, I say that every wooden ship that we have now afloat, if she is not covered with a sufficient plating of iron to protect her against incendiary and explosive shells—and we know, by the experiments of the "Simoom" what the $\frac{4}{5}$ plates will do—such must, in my humble opinion, be the inevitable result; and, taking that for granted, as Mr. Samuda is an iron-ship builder, I suppose he would be very well pleased to have a contract for plating half a dozen of our frigates, and it would not be a bad thing for him. Therefore, he is actually concerned in the question, as every iron-ship builder is concerned, in the question—not only in the change which must now take place from wood to iron with regard to floating batteries and Iron-cased Ships, but I believe with regard to every wooden ship which we possess. Now, supposing that our Iron-cased Ships—especially the men-at-arms, as I have called them—should merely replace our present line-of-battle ships, we should have then at least 500 wooden ships performing all the duties of men-of-war throughout the whole quarters of the world, all liable to destruction the first time they went into action; and I say that there again is a very large amount of prospective work which Mr. Samuda and our other iron-ship builders may be called upon to assist the country in, above and beyond the single point of the armour for the iron ships upon which he laid so much stress. I may just make this one final remark, upon the assumption that all our iron ships should be covered merely with $\frac{4}{5}$ plates.

There are a series of experiments in Sir Howard Douglas's work, showing that an iron plate of 1½ inch, as it were, emasculates the conical or rifle shell as perfectly as the ¾ plate does the spherical one; and therefore I mean to say that the rifle-shells of Sir William Armstrong's 100-pounder guns would be broken to pieces against a 1½-inch plate. Therefore we have there a plating for our ships with which they may go into action with perfect certainty that neither spherical nor conical shells from rifle-guns—nor, I believe, Martin's shells, or molten-iron shells—would have any effect upon them. But, when making the latter assertion, I beg to be understood in this way: no experiment whatever has been made with respect to the breaking of a Martin shell against an iron plate. I believe, if the experiment has been made at all, it has been against armour plate, and not against plating of which the ship would be built; and therefore I am not prepared to speak positively upon that point; neither, again, am I prepared to say that during the period—how long it may be I do not know—in which plates must be backed by timber it becomes a serious question to know whether the molten iron would be left behind outside the plate which broke the shell to pieces, in the same way that the powder is left outside. That is a matter which I believe ought to be ascertained as soon as possible; for I was down to see the "Warrior" to-day, and I saw things which would make it very awkward indeed if it should happen that, although the shell might be broken in two pieces by the plate outside, the contents of the shell, in the shape of the molten iron, should come inside. Sir Howard Douglas, in his postscript, endeavours, I know, to do away with the force and strength of that which he states in his main work with regard to the effects of the shells at Sebastopol; and one of his conclusions is to the effect that, although the shells are kept perfectly out, yet, if the shot is not kept out, it is of no use keeping the shell out. Now, I beg to say that I am not of those who can subscribe to that conclusion. I should be too happy to be kept from being blown to pieces by Moorsom's or concussion, or being set on fire by Martin's shells; and I should not wish to be exposed to that risk simply because I could not keep the pieces of solid shot out of the ship. Sir Howard Douglas's conclusion is one, therefore, to which, I think, very few people will subscribe.

I may mention now what my friend and brother officer, Captain Stopford, has just mentioned about the shell practice at Portsmouth, and from the "Excellent." All I can say about it is, I am very glad to find that there are people who do know it as well as I do, because it is a confirmation of my statement; but those six words in the postscript of Sir Howard Douglas's work are the sole published notice given to the world to this instant of what took place. I put into the hands of my gallant friend the Chairman the other day, a letter which I sent to the *Times* so soon as I got such an amount of official, or at least of authorised knowledge of the fact, as would enable me to meet a challenge if it had been made; and I should have been too happy to have referred to my friend to support me if I had been aware that he, or anybody else, was acquainted with the facts.

Capt. STOPFORD.—There was no order given at Portsmouth, as far as I know, with regard to secresy. All the collegians were allowed to go on board; the matter was as openly discussed as anything else was afterwards.

Capt. HALSTED.—It has not been discussed, at all events in public, and it is not to be found in print. I think there cannot be a single shadow of a doubt, that had the thing been known it would not have been left where it was. I stated elsewhere in 1851, that there was an express motion made in the House of Commons for a return of these very experiments which my friend states as having been made at Portsmouth, to include all the effects of shells as well as shot. I quoted in my lecture of Monday last the very words of the motion, and the return did not produce any information whatever of the sort. It was what is termed in the House of Commons "still-born," and was allowed to lie upon the table; it did not contain the information for which it had been moved; and so much was the public unaware of the fact, that every effort was made to procure the publication of the result of these experiments. There was an association of influential gentlemen of great affluence all concerned in the construction of iron ships, who, upon the faith of this rumour, as I have stated it, that such results had been procured, associated themselves for the purpose of insisting upon a fair, and open, and practical experiment—shot for shot, shell for shell, red hot for red hot—upon a hulk of wood and upon a ship of iron, which ship of iron they themselves subscribed for and actually constructed; and although the authorities were pressed to enforce the trial, the trial never took place, and the point was surrendered,

and it was said, "We will relieve iron ships from the ban against them, and they *may* perform mail contract service." No doubt it is, however, a remarkable thing that in Sir Howard Douglas's work, where he gives the minutest detail of every one of these experiments, and lays it down that the knowledge of every fact established in his experiments ought to be made known to the whole community as of immense importance, not a single syllable is to be found there of the breaking of the Moorsom and time-fused shells, he just keeps within those six words in his postscript; and if it had not been there, I should not have been enabled to make use of it in the way I had, unless I had known it from my friend and got his report; but I wished to support my views, which I was then in that portion of my lecture bringing before the public, by printed records rather than a statement of my own views.

The CHAIRMAN.—I suppose upon so important a subject it might be expected of me that I should review what has been said. I am not prepared to do so just now; I think it better that the whole subject should be discussed first. I think it a very serious matter to propose that the whole navy of England should be changed at once. I do not think that some of the arguments have been answered, and I must take exception to very much of what Mr. Samuda has said. I may have misunderstood him, although he was exceedingly clear in his statements; I am sure we all feel very much indebted to him, but I think there are questions arising from what he said, which to me as a sailor are very important, and I should like to make inquiries upon the subject before I say much about it. I would, however, give one illustration. He said, as an instance of the value of iron ships, that at Lloyd's, who are very good judges in these matters, and are very good authorities, charge for insurance on ordinary vessels was from six to eight per cent. and that the P. and O. Company found from experience that the cost for insuring themselves was only 2 per cent. Now, if he had given us the relative charge of Lloyd's, it would have given us Lloyd's opinion; but he has only given us the result of the P. and O. Company's management, because that is what it really is; theirs are fine large ships, well managed, with a definite trade, frequently docked, and thoroughly well managed and commanded. That is no evidence with respect to iron ships generally. The question of management is involved; but, as a sailor, I feel that this opens a very important question. The enormous loss of life and property arising from bad ships and bad management is so clear from the statement lately made, that really I feel—and I have long felt, without knowing that the state of things was so grievous—I feel that there ought to be legislative interference. Do I understand from Capt. Halsted that the bottom plates of the "Warrior" were only $\frac{4}{8}$?

Capt. HALSTED.—No; those plates which go into action.

Capt. FORD.—Capt. Halsted has referred to me this evening. It was not at all my intention to have said a word; but, having alluded to me, if you will permit me, I will make a few remarks. I heard Capt. Halsted deliver his lecture on Monday, and I heard the observations of others afterwards, and to the extent of nine-tenths I agree in all he said. In some things, of course, I differ from him; but what I wish to make a few remarks about, is with reference to what he says of the "Warrior." Being one of the managing directors of the Company who were building the "Warrior," and a sailor, and a pretty old one, I think I may venture to say a few words upon the subject. Now, if I understood Capt. Halsted, he objected to the wood backing behind the armour-plates on the "Terror."

Capt. HALSTED.—I merely illustrated the question. I did not make an objection to it. It is a matter of necessity. We have got it; we cannot get away from it.

Capt. FORD.—I understood that you objected mostly to the wooden backing, in consequence of the water pouring in between the plates and communicating with the wooden backing behind, and thereby possibly creating rot, and so on.

Capt. HALSTED.—I will put myself right. I am not objecting to the wooden backing. Mr. Samuda's is a question of backing. It was mentioned here the other day, and also at the Institution of Naval Architects, when this subject was discussed. Moreover, I have brought that forward for the purpose of showing the absolute practical value of the backing.

Capt. FORD.—But I think you made one great objection—that the water was pouring in and out between the plates.

Capt. HALSTED.—Yes.

Capt. FORD.—I am going simply to make a remark as regards the "Warrior,"

because the "Warrior" is the great subject of the day; and, on account of the great cost of the "Warrior," it is necessary the public should have all the information that can be given them. Now, the "Warrior's" iron coating, the armour-plates, are tongued and grooved, and are then caulked, and I believe not a drop of water can get through that armour to the wooden backing, although it does not really form a part of the strength of the ship; because, as you know, first of all, the iron ship is perfectly built, and putting on these iron plates outside is like a man putting on his coat of armour afterwards. But, still, the armour of the "Warrior" is so carefully, and so expensively, put on in every respect, that it is like one solid plate. Then it is caulked with its own metal, so that I do not believe one drop of water can get through the armour to the wood any more than it can to any other part of the ship. I think you know that the teak backing behind the "Warrior," as it now stands, is perfectly preserved. Whether the teak backing is the right sort of thing to put behind it, and will offer more resistance, I will not venture to discuss; but, as regards the perfect way that the Admiralty have decided to put the armour upon the wooden backing, I must say that I think they have done all they possibly can, and have done the best they can, so far as my humble judgment goes. I come now to another remark. I believe you inferred also that our present wooden ships in the Navy might very advantageously be coated with plates of iron of certain thicknesses—say, 1½ inch; but this should not be done till war is imminent, as we should at any time have the power to coat with 1-inch or 1½-inch coating every ship in the Navy in a week. But, mark my words, if you attempt to do it now, and these ships go on from year to year, your timbers will rot under that iron—the ships will be entirely decayed. Now, if the Government should think of such a thing, let them take their moulds, and prepare plates and lay them up in store in the dockyards, ready in twenty-four hours to put them on their ships; but don't let them attempt to do it now, or the wooden ships will rot as sure as fate.

Capt. COLLINSON.—The teak ships will take it without rotting, and they might be experimented upon at once.

Capt. FORD.—Yes; but don't do that for the fleet. Fit your plates, and lay them in store, and in forty-eight hours you can cover any ship in the Navy. I think, Capt. Halsted, you compared somewhat the construction of the "Warrior" to that of the "Simoom," or that she was another "Simoom?"

Capt. HALSTED.—No; I did not do that exactly.

Capt. FORD.—But let me say in defence of the "Warrior" and the Admiralty, that the "Warrior" is infinitely stronger and infinitely superior to the "Simoom," or the generality of the ships of the class of that day. The "Warrior," believe me, is the most perfect specimen of iron-ship building that ever was brought out, and certainly does the Admiralty an immense deal of credit.

The CHAIRMAN.—May I ask what is the thickness of the bottom plates of the "Warrior?"

Capt. FORD.—From 1½ inch. Five-eighths is the weakest plate in the ship. Behind the armour of the "Warrior" the whole plating is ⅝.

Capt. HALSTED.—Nothing but ⅝? Is it so beyond the bulkheads upon each deck, fore and aft? There is a small portion of ⅝ close to the junction where the armour is embodied, as it were, into that portion which is not the armour.

Capt. FORD.—Capt. Halsted very properly observed that the two ends of the ship are not protected by armour-plates: but there is an object in that.

Capt. HALSTED.—I know there is; and it is my intention, in the continuation of the lectures, to give all my opinions especially about the "Warrior" and her class, and I may suggest that I shall be happy to hear these remarks then, and it will be better to defer them till that occasion. I was merely illustrating Mr. Samuda's charge against me, as to saying that nobody wanted to know anything about ⅝ plate, and that all that people wanted to know was about armour-plate. I illustrated the matter in this way: I said that, if he had had the contract for the "Warrior," instead of yourselves, he would have found that he had a great deal to do with ⅝ plate. That was the only way in which I mentioned it; and, when I mentioned that, it was my special intention by and bye, in another lecture, to treat upon that point; and I would suggest to you whether it would not be desirable to criticise my views then, when I expressly state them with reference to the "Warrior."

Capt. FORD.—Are you going to allude to the reasons why the two ends are not

coated? Because I understand you condemn the "Warrior" for not being coated all round.

Capt. HALSTED.—I intend to say everything I can about the "Warrior." I approve of the "Warrior" not being so, because she condemns that condemnation.

Capt. FORD.—I approve of it in this instance as a sailor. I say that you cannot otherwise get the speed which is so desirable. You want more classes of iron-coated ships than one. Now, you will never get anything in speed to equal the "Warrior," and that class which simply carry their weights in the centre, as she does, with the two ends unloaded; for I believe you might just as soon put a weight on a race-horse's neck and tail as load the two ends of a ship of that sort. In consequence of the two ends of the "Warrior" being light, she will have a greater speed than anything you can oppose to her if you load the two ends.

Monday, April 8th, 1861.

Captain E. G. FISHBOURNE, R.N. C.B. in the Chair.

IRON-CASED SHIPS—*continued.*

THE EXPERIMENTS ON "THE TRUSTY" 1859 AND 1860—CONICAL SHOT ONLY.

IN the first naval campaign of the late Russian war, and up to the year 1855, the French and English force of Screw-ships-of-the-line in the Baltic and Black Seas together stood respectively at eighteen English to five French, or, if we except our four Block-ships, at fourteen to five, being in the proportion of three to one nearly. But by the end of 1858, up to which time the relative strengths were ascertained and presented to Parliament by Lord Derby's Committee, it was found that the two Navies had become of equal force in Screw liners, while that of France was superior in Frigates by a proportion of one-third; besides the four "Iron-cased Ships" then building by her, while England's first one was not yet begun. By the opening of this present year, however, and by great and creditable efforts, the parity of strength of 1859 has again been brought, or nearly so, to those proportions in favour of England on the maintenance of which her Maritime Security has always, until lately, been held to depend; and in respect to Screw line-of-battle ships, as the special exponents of Naval Power, England's force now nearly doubles once more that of her great maritime Neighbour.

But it is important to remember that the restoration of these proportions has been effected by purely accidental circumstances, which have helped us out of our critical position this once, but which can never do so again. The discovery of 1859 fortunately found this Country with a far larger remainder of the former fleet of Sailing line-of-battle ships in sound condition than was the case in France; and, but for the ready means which was thus afforded of converting these into Screws, the difference in the strength of the two Navies in this principal arm must have been so slight, even at the present day, that the addition of the fourteen sail of Russian

Screw-liners to those of France would have placed England in the Channel and Mediterranean in a position of numerical inferiority, even if her whole Fleet had been confined to those waters. And, indeed, when the Italian campaign and the Baltic navigation opened simultaneously in 1859, and a strong rumour was current of a secret treaty between France and Russia, there were many minds to whom was known the true state of unpreparedness we then were in, which were by no means free from deep anxiety as to what that year might bring forth on scenes much closer to our own hearths and homes than the plains of Lombardy.

Thus, the year 1855 seems to mark the commencement of a period when the traditional policy of England in respect to the international strength of her Fleet underwent some great and deliberate change; and the circumstances connected with the present international position in respect to our force in that new Engine of naval war which is to supersede the wooden Screw liner seems also to point to the same conclusion. There were always sufficient signs to show that the official faith of England and that of France in the competency of the "Floating Batteries" of 1855 for their proposed work were of very different degrees of strength: there was always a tone of depreciation as to the efficiency of the proof sustained by the French vessels before Kinburn; there was much indecision and reluctance in subjecting any one of our own vessels to effective shot-proof; even when so subjected, but little interest was shown in the remarkable powers of resistance displayed, which, when spoken of, seemed to excite annoyance and disappointment, rather than any other feelings. Allusion to these powers was always met by pointing to the entirely different results necessarily produced by placing in armour the decrepid Portsmouth veterans, and then firing at frames which were never equal nor intended, even when young, to bear treatment half so severe as that under which they necessarily succumbed in their old age; and, lastly, it is not until now, when the demand has been made by the one loud and unanimous cry of the Country, that the construction of "Iron-cased Ships," as a necessity, is reluctantly conceded. And whether there be any true earnest at this moment to place England in respect to her Fleet of this description in the same position of numerical superiority to France which by long tradition her security has been held to depend upon, may well be doubted by others as well as myself, who have but the signs they see around them whereby to guide their judgment.

That "tradition" of now some 150 years of practical proof has ever based England's maritime, and therefore essential, security on her possession of a Navy of double the force to that of France, in whatever might be the description of ship regarded as the representative of Naval power. And as throughout that period such representation has been vested, as the title implies, with the Line-of-battle ship, so it follows, that, if it be that description of ship which is to be superseded by the new engine, then England's security must depend on her possession of an Iron-cased Fleet of double the numerical force of that of France; unless, indeed, any facts or circumstances can be pointed to which justify the conclusion that in the present day such security may wisely be entrusted to lower international proportions. Now the two main considerations which ever determined the larger proportions were—First, the number and value of those distant Possessions, our vital commerce with which made it requisite for us to place them under

the defence of detached portions of our Fleet; and, if the necessity for that defence is still to be measured by the value of the property to be defended, then, whether it be our Columbian or our Australian "nuggets," our Chinese trade, or our Indian Empire, it is hard to say that such necessity is less now than it has ever been in times past. Secondly; while so much of our force is thus necessarily detached, there is the consideration of our having to meet, nearer home, a combination of more than one, or even of all other Navies together, added to that of France. And, if we regard the enormous floating wealth which England now exposes to "war risk" in her ever-increasing Ocean trade, there are circumstances of to-day offering as great a temptation as ever,—and assuring our complete humiliation as certainly as ever,—if by means of any such combination our Colonies and Commerce should be made a prey of by even a two months' supercession of our Maritime Supremacy.

But, if anything could be wanting to prove how perfectly our great Naval rival herself regards our security as depending on *at least* our traditional amount of superiority, it is to be seen in the frank, open, and systematic determination, with which since 1849 she has studied and applied the purposed means of wresting our supremacy from us, even though it be based on such acknowledged superiority; and as year by year, and step by step, she matures her plans, it may be well and wise to note the confidence with which she relies, even single-handed, on effecting our humiliation by her Naval success within the first period of any possible war between us. For the unmistakeable evidence of all this, and for a description of the truly formidable counsels and efforts by which she is steadily advancing in preparations for her avowed object—and in nothing more evidently so than in her determination to keep that "lead" we have openly surrendered to her in the construction of an Iron-cased Fleet—I venture earnestly to invite all who hear or read these Lectures, to the thoughtful perusal of those truly patriotic pages which, under the title of "The Faults and the Defaults of the Naval Administration," have recently been put before us all; and of those pages none seem to be to me more valuable than those few introductory ones wherein the writer points so forcibly to the popular error, "that England is safe while uninvaded;" while in reality, from the very nature of her existence, the destruction of her Power may be accomplished by the loss of her Naval Supremacy alone, without even an attempt at her invasion, and without its being practicable to fire even one volunteer rifle in its defence.

The construction and maintenance of a fleet of the new description of ship, double in numerical force to that of France, is therefore as essential to our safety to-day as has been that same scale of superiority throughout the long reign of the wooden line-of-battle ship; and if it be true that France has now, built or building, fifteen "Iron-cased Ships," while England certainly has but seven even in contemplation,—then is this most serious fact forced on our consideration, that the traditional proportions of relative superiority between the two Navies in that engine which is the special exponent of Naval Force are actually reversed; and the alarm created by the discovery of our relative equality in 1859 has yet a more formidable foundation in the recent official announcement to the Country of our actual inferiority as involved in the above relative numbers.

Nor is it that this humiliating position is limited to the fact that for the first time in our international histories our Rival has been allowed to take advantage of our deep absorption in party strifes for Place and Power, to sap the foundation of our National security; but, for the first time in the history of the two Navies, that of France can now show nearly a twelve-month's practical knowledge and experience in the properties and management of the special Engine of naval war, while not an Officer or Seaman in the Navy of England can show now,—nor for months to come will be able to show,—the experience of a day. Nor does the difference in our relative positions end even here. The seven "Iron-cased Ships," now building or to be built in England, are of three several plans and descriptions, all so distinct that each will demand their own separate experience, and, until the relative values of these be compared and determined, our path must still be perplexed and dark before us; with the chance even then, that neither of the three pair of present specimens may supply us with more than the negative light of *avoiding to build any more like them*; while it is evident, from the decided measures of our great Neighbour, that his year of practical knowledge in advance of us, has afforded him light enough to mature his first stage of experience, and give confidence as to the requisite modifications to be embodied into his second stage.

Is it not well then to inquire, Is this relative position of the two Countries in naval matters the result on our part of mere blind inadvertence, or is it indeed the effect of some great and deliberate change in our traditional principles as before adverted to? We have seen in these Lectures that from 1840 to 1845 it was anxiously endeavoured to secure for our Navy all the prospective improvements and advantages which the introduction of iron was throughout that period considered to hold out; and the traditional practice of England's Navy in taking and keeping "the lead" in all "naval improvements," to the obvious increase of its superiority over that of all others, was thus duly acted on up to that latter date. Again, it was in 1849 that the first finished Screw-liner the "Hogue" was seen making her first sea-trip across to Ireland, and from that time to 1855 England's efforts in securing "the lead" in this great "naval improvement" also were such, as before stated, that when France could provide but five such ships for experience in actual war, England sent eighteen; so that, down to this latter year, our traditional doctrine was fully acted on still. But at that time we first heard, and since that time we nothing else have heard, on each annual presentation of the Estimates, but the anti-traditional doctrine, "That it is not England's 'policy' to take 'the lead' in Naval improvements;" and to this avowed "policy," therefore, which practically does make over, and actually has made over, to Maritime Power No. 2 that which theretofore Maritime Power No. 1 had jealously secured for her own essential defence, is unmistakeably due our position of *equality* in Screw-liners which was announced in 1858; and our yet more unparalleled position of *inferiority* in the substitutes for those Screw-liners, which was announced with equally unparalleled equanimity in this present 1861.

England has but three appropriate docks in those Naval Arsenals of hers, which to eyes that cannot see across the Channel may still seem "great;" and if, as present signs seem to show, she should limit her efforts for the construction of her new Fleet to such "Warriors" as may be

built in these three Public docks, then we may expect to see the twice thirty available building-places of our great Private iron yards, with all the superior skill of their long-experienced Establishments, fully occupied in the construction of the "Warrior" fleets for all other Countries than their own—probably for that of France itself—with a result which must make it hopeless ever to expect regaining the security of that traditional Maritime Supremacy which thus will have been so irretrievably surrendered.

How far the actual supercession of wooden Screw-ships-of-the-line by Iron-cased Screw-Ships—at present of one deck only*—can be regarded as a reality, depends no doubt on the comparative liability to destruction in battle of the two descriptions of ship. This question as regards all "shell-fire"—whether time-fuzed, concussion, or of molten iron—we have already seen to be determined, by Sir Howard Douglas himself, in favour not only of 4-inch plates, but even of $\frac{5}{8}$-plates as in the "Simoom" experiments of 1850,—confirmed by the adoption of those same plates for the batteries of the semi-"Simoom" "Warriors" of 1859–60. But as those experiments were made with *spherical shells only*, it may be well here to restate the "Conclusion" given in Article 446 of the Naval Gunnery as regards *conical rifled shells also*, and which is as follows:—

"Some interesting experiments have recently been made against iron plates by Sir William Armstrong's new 80-pound shells—against a target resembling the scantling of a 50-gun frigate, covered with plates of iron of various descriptions of $1\frac{1}{2}$, 2, $2\frac{1}{2}$, and 3 inches thick, bolted to the timber with wrought-iron screws and rivets. The Armstrong shell, fired with a charge of 10 pounds, pierced $1\frac{1}{2}$-inch and 2-inch plates without failure. When fired against the 3-inch plates, one-half only of the number fired penetrated the plates, but not the timber, driving pieces of the plates from 1 foot to 14 inches into the timber. An 8-inch spherical shell, fired with a charge of 16 pounds against the $2\frac{1}{2}$-inch plates, made only a circular crack around the point of impact. *No shell penetrated in an unbroken state, and did not, therefore, show the effects that a live shell would have produced by bursting between the decks, or, what is still more destructive, lodging in the side and then bursting.*"

To the which quotation I will only add that it seems most desirable to ascertain at once, by open and conclusive experiment, the thickness of plate which will so far exclude the molten contents of the Martin shell as to protect the timbering behind the plates from combustion, wherever timber is used.

Having thus disposed, *for the present*, of all descriptions of "shell-fire," we have now arrived at the amount of protection afforded by the sides of "Iron-cased Ships" against penetration by shot, taking for our guide the effects of the several firings at the sides of the "Trusty" by Sir William Armstrong's 32-pounder, and 80-pounder, and Mr. Whitworth's 80-pounder; no other Guns than these having as yet proved their power against those sides, and those sides being the only ones of a real ship built of combined wood and iron expressly to afford such protection, which as yet have been fired at in England, with two partial exceptions to which I will hereafter refer. And, to prevent all misunderstanding as to ultimate conclusions, I will here state what I conceive to be the true practical question at issue between the "Iron-cased Ship" and the wooden "Ship-of-the-line;" and the sense, there-

* While these Lectures have been in progress, it has been ascertained, for the first time, that the French "Magenta" and "Solferino" are formidable Iron-cased Ships on two decks, and as such will be lauched before these Lectures are published.

fore, in which I hold that issue to have been illustrated by the experiments now before us.

I hold the destruction of the opponent ship and her contents to be the mutual object in every Naval engagement, *the issue of which will therefore be determined, all other circumstances being equal, by the relative protection against the means of destruction which each ship possesses in the nature of her sides*, so that the problem, in its simplest form, as I understand it, may be stated thus:—

Here are two structures of wood, perfectly equal in size, substance, material, and combination; both of them have to sustain, under equal circumstances, a fire of Artillery perfectly equal in calibre, nature of missile, and precision; both structures afford protection to bodies of men, perfectly equal in number, and in mental, physical, and professional capacity; and it is these two bodies who from their relative positions of protection mutually employ their Artillery for the destruction of the opponent structure and all it protects. These two structures, being ships of perfectly equal qualities in every other respect except that the one possesses the additional protection to her sides of an iron armour four inches thick, while the other possesses no such protection at all;—which of the two is most likely, within any given time, either to destroy her opponent and all she protects, or compel her to cease the contest in order to avoid such destruction?

In placing the question thus, I believe I place it in its true common-sense point of view. The collateral questions of wooden bottoms or iron ones; of this or that thickness of armour; whether backed with wood or without it; of inferior or superior steam speed; and of superior or inferior Artillery force; involve conditions which I admit to be of the greatest importance, and the study and correct application of them,—to be determined at first by the aid of TRUE experiments,—according as they shall be successfully combined with the successful solution of those terrible problems which the construction of such ships "at all" imposes on the Naval Architect, must undoubtedly determine the success or failure of individuals, or even of whole classes of the species; but still the terms I have stated constitute those by which the main decision between the two descriptions of ship must, I think, be ruled; and the direction in which that decision should be ruled, will, I think, become equally undoubted from the details I now proceed to specify.

The "Trusty" has the timber scantling of the lower deck of a 90-gun ship, viz. 10-inch oak timbers, with 8-inch outside planking, and 7-inch inner planking, the inter-spaces of the timbers being about 5 inches;—and thus the wooden structure of this vessel is not so solid, although it is thicker than the timbering of the "Warrior" and her sisters. She was expressly built as one of the "Floating Batteries" of 1855, with her sides protected by 4-inch iron armour in plates, the largest of which are 10½ feet long by nearly 3 feet wide. In the summer of 1856 she was pre-prepared for being fired at by filling up certain of her ports with stout timber covered with plates of equal thickness as on the sides, so as to prevent unnecessary destruction by shot entering the ports, and in the autumn of that year every requisite arrangement was made for laying before the fire of the 95-cwt. solid shot 68-pounder guns at Shoeburyness; but other

counsels prevailed when all was ready, and instead of the real ship being subjected to practical proof, a fragmentary representation of her was constructed at Woolwich and there fired at in her stead, and I will here request attention to one point only of the practical difference between the vessel herself and the representative thus put to proof for her.

Had the "Trusty" been actually engaged at Kinburn, or in any real conflict, she would have presented a mass,—say an anvil to be hammered at,—of at least 1,700 tons weight, while by the account of the experiment, together with the diagram in page 396 of the Naval Gunnery, we are told that the mass,—say anvil again,—which was actually hammered at on the occasion, was but 30 tons, *or more than fifty-six times less in weight* than the reality it was supposed to represent; and, accordingly, on receiving each shot, we are further told that "it was driven bodily back to an extent which amounted to several feet at the end of the experiments," which experiments, according to the account, concluded after twenty-four rounds; so that this representative target was in truth little else than a shot itself, which, as it could not easily have been "rammed home" into the gun, was subjected to the amount of projection which a charge of 16lbs. of powder could produce on it, by employing a 68lb. shot to act as a "medium." The effects of impact on this "little anvil," are, of course, held to show truly what would be the effects of similar impacts on the "big anvil;" and thus, as in every other case except the one I am here reviewing, our so-called experiments, with true consistency, seem almost purposely to have been such as should afford results as far removed as possible from the true practical information we were supposed to be seeking after.

After this vicarious treatment in 1856, it was not till the first week of January, 1859, that the "Trusty" herself was at length put to real proof, off Shoeburyness, before Sir William Armstrong's 32-pounder gun, which had then given a range of upwards of 9,000 yards, the gun being embarked for the purpose in a gun-boat. The illustration (A) Plate I. shows the effects of the firing on this occasion, only the more important details of which I propose to occupy you with. The firing commenced from a position at right angles to the side at a distance of 450 yards, at which one shot of steel, No. 8 in the illustration, effected a lodgment in a joint of the armour; and as its original length had been 10½ inches, and its external projection measured 6 inches, it was considered to have had a peep to the extent of half an inch at the timber behind the armour; but as it was shaken overboard by the jar of a subsequent shot on the same plate, its real penetration was not known, but the joint-edges of the two plates were broken throughout their thickness. After this shot the distance of fire was reduced to 200 yards; and as no approach to penetration was made at this, more than at the former distance, the Gun-boat was gotten under-weigh, and the remaining shots were delivered at 50 yards and even closer, all hands but the actual gunners being sent below out of the risk of splinters, some of which of large size flew far over the Gun-boat. The shot of steel marked as No. 13 was delivered at about 50 yards, and lodged in the joints of the two small plates, filling one of the ports, which it forced apart against the caulking of their upper and lower edges respectively. The external projection of this shot was 4 inches, and on being pulled out of its lodgment it was found to be "set up" from 10½ inches to 9 inches,

Starboard Side of Trust

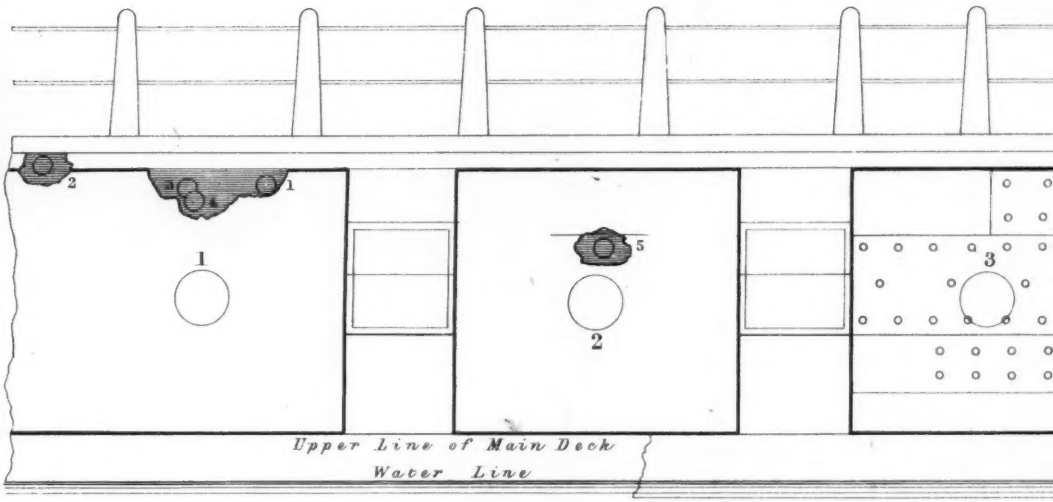
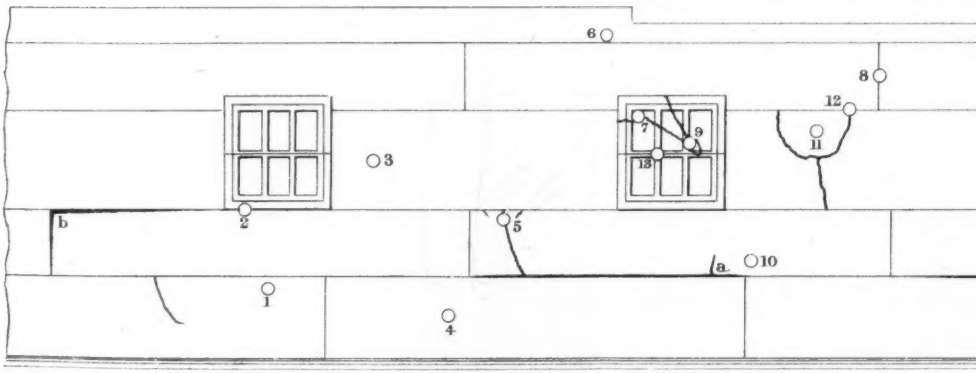


ILLUSTRATION A.

Starboard Side of Trusty as fired at by Armstrong 32 Pounder Gun. Jan

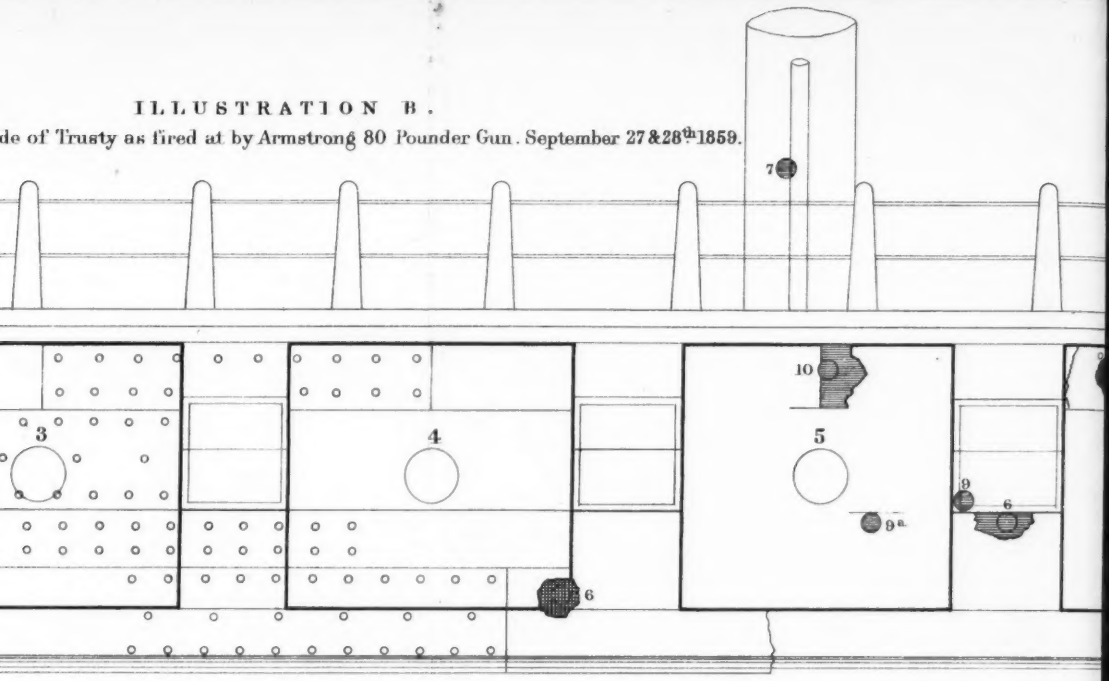


Explanation.

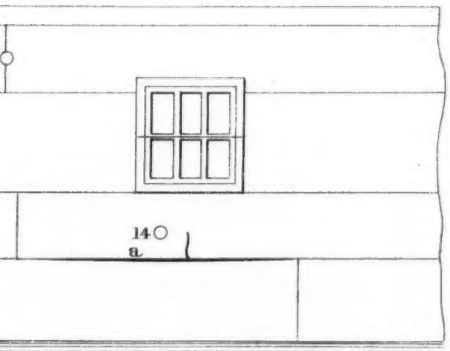
The parts shewn thus [symbol] *and numbered 1 to 10 denote the places struck at 400 Yards distance, 1st a*
Dº Dº [symbol] *Dº 1 to 9 Dº at 200 Yards Dº 2nd*
The part Dº [symbol] *Dº II place by shot fired at an Angle o*
9.ª 9.ª Places struck on the opposite side of the deck by the shots 9. 9. after they had passed through

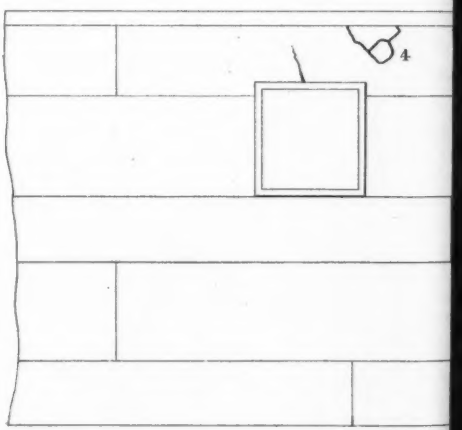
ILLUSTRATION B.

de of Trusty as fired at by Armstrong 80 Pounder Gun. September 27 & 28th 1859.



der Gun. January 1859.





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D° 2nd days practice
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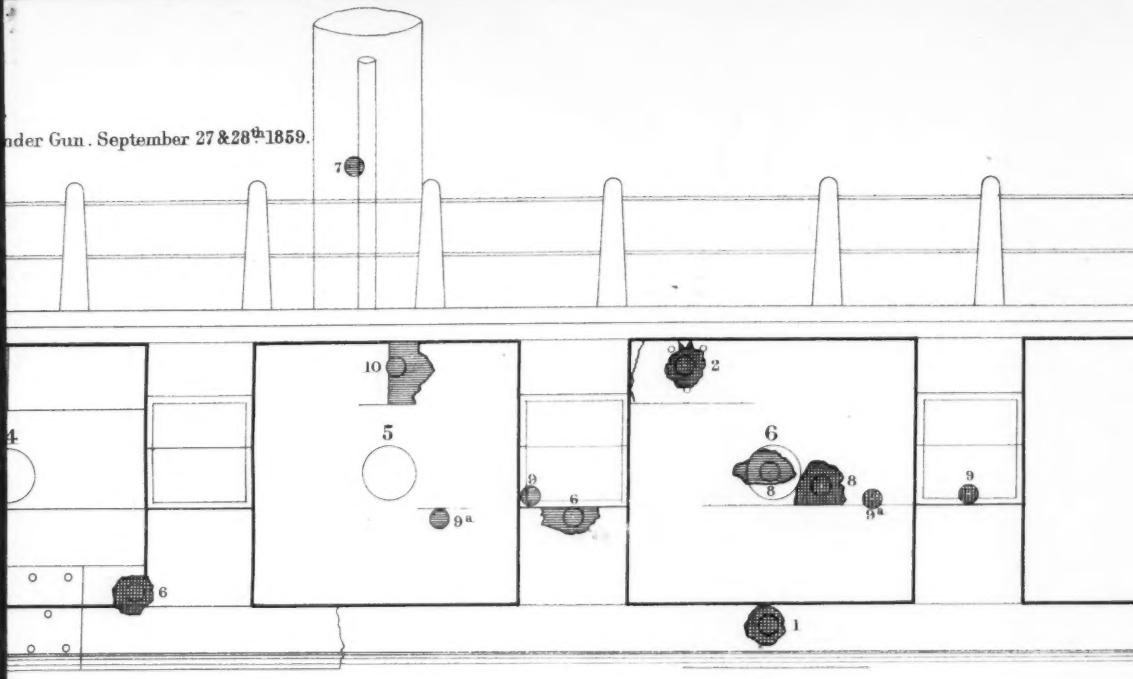
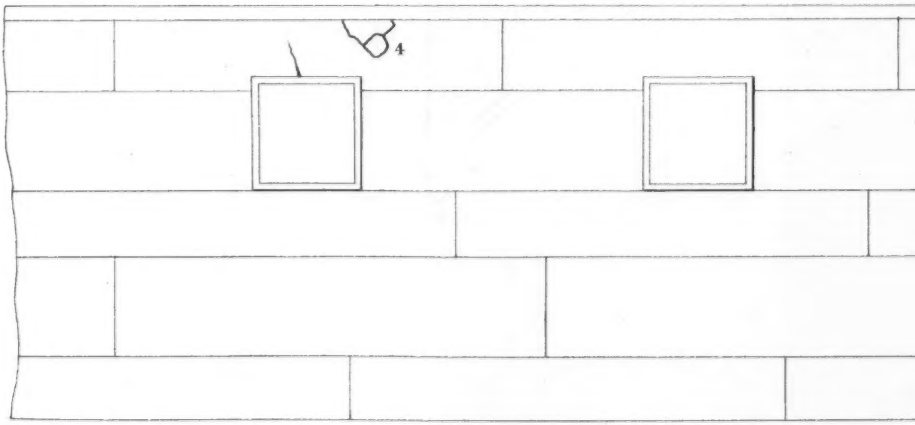
nder Gun. September 27 & 28th 1859.



ILLUSTRAT

Port Side of Trusty as fired at by the W



SCAL

0 5 10

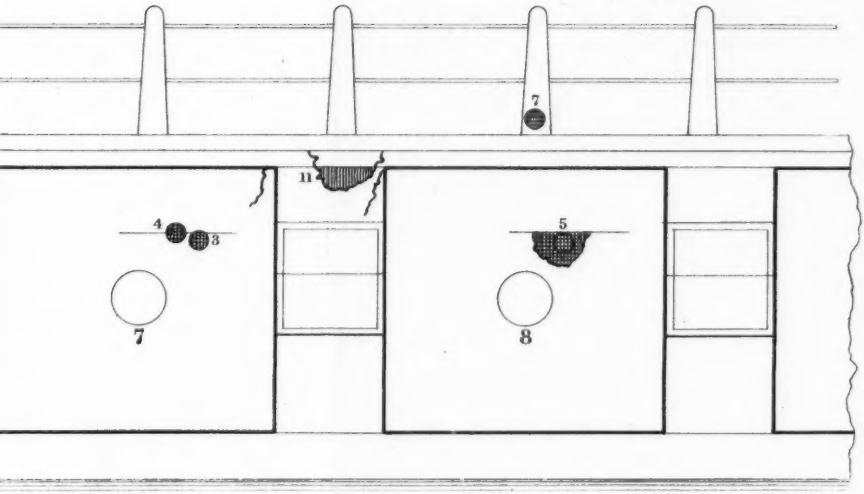
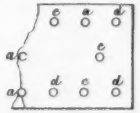


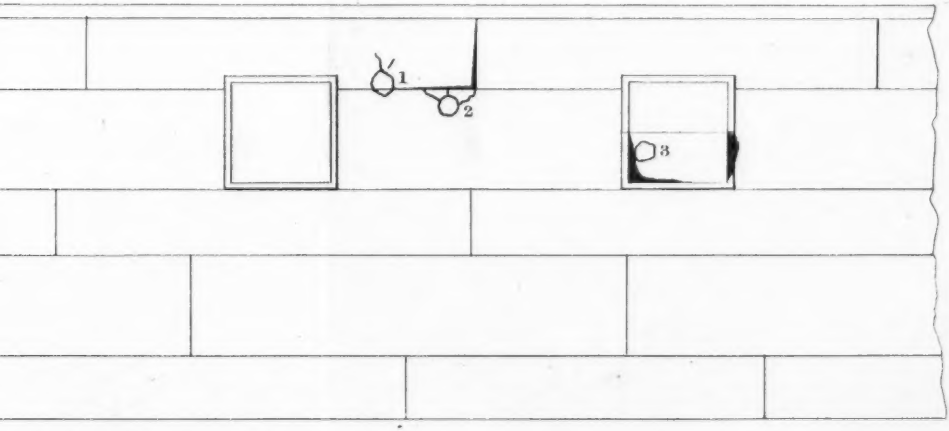
ILLUSTRATION C



Piece of plate driven off by 9th shot on 2nd days firing

S T R A T I O N D .

at by the Whitworth 80 Pounder Gun. June 1860.



S C A L E .

20 30 FEET

J.R.Jobbins.

so that in all probability the front of No. 8 shot had not reached the inner surface of the armour. The shot No. 11, which was nearly the last fired, and one of the closest, was of wrought iron, and the largest specimen on the table, which is a fragment of it, exhibits the effects of the armour with curious completeness; the whole length of the shot is there, the "lands and furrows" for retaining the external lead, being complete, although crushed up; so is the truncated portion of the coned head of the shot, as well as the actual impact on the armour. The shot used on this experiment were of cast iron, wrought iron, and steel, none of them "flat-headed," but all of them with their cone-heads more or less truncated: the above fragment, and the whole shot No. 13, are all that were saved, to the best of my belief, out of the whole fourteen fired, and the complete practical protection of the side was not even seriously endangered. The amount of indentation produced on the armour varied from $\frac{3}{8}$ of an inch in the cases of shots Nos. 2, 4, and 14, to 2 inches in that of No. 9; the cracks, where produced, are accurately shown from drawings taken a few days after the firing; and the forcing in of the plates at "*a*" "*a*"—the cause of which was an after discovery—amounted to $1\frac{1}{2}$ and $1\frac{1}{4}$ inches respectively.

A complete practical illustration took place on this occasion of the difference of effect between firing at small "anvils" or at large ones,—at ships or their fragments. As the Conductors of the experiments judged it likely, from the power of the gun, that the ship might be penetrated; and as this, if it should take place at the water-line, might let much water into the ship before her Crew could get on board to the pumps, an Officer, with a Carpenter and his mate, took post on board, to notice the effects of the first shots. They sat in perfect security on the fore-hold ladder awaiting the first round, and so soon as it was fired all three simultaneously ejaculated—"They've missed her;" and the certainty of the "miss" was rendered only doubtful by the fall from the main deck beams of one or two loose scales of whitewash, and one or two of rust down the chimney, which closely followed the shot, but all of which might equally have been detached by the mere concussion of such near firing. Four shots were thus fired without producing any shock in the least degree sensible to those on board, and the Carpenter and his mate were subsequently permitted to continue throughout the entire experiment, quietly cooking and eating their dinner in the galley on the main-deck. Making every allowance for the heavier shot and charges fired at the Woolwich 30 ton "anvil," a similar seat on one of its timber supports, as it was driven back *en masse* at each shot, would not, I think, have been attended with quite the same impunity of effect to the sitters. The charge used throughout this trial was 6 lbs.

On the 27th and 28th of September following the firing took place which is shown in the illustration (B). The gun on this occasion was Sir William Armstrong's first 80-pounder, out of which about fifty rounds had been fired before its embarkation in the gun-boat; its power had also been exhibited by a range of more than 9,000 yards. The distance of the first day's firing was 400 yards, the position, as on the former occasion, being kept as near as possible at right angles to the side fired at, by poles erected in the vessel for that purpose. The Starboard side of the vessel was selected for execution as before, but it was purposely provided not to fire at the same part as had sustained the fire of the 32-pounder, so that

the effects in the two cases might be kept perfectly distinct for subsequent examination or comparison, and the ports of the portion fired at were not, as before, "filled in," neither were there any strutts or shores to support the side against the combings, as before; but the side fired at was completely "*au naturel;*" and I may here say, once for all, that 12 lb. charges were used throughout; the diameter of all shot being 6 inches.

In the diagram, each days' firing is differently coloured; that of the first day being "blue," and that of the second "red." The continuous white line close to the water represents the portion of the vessel below the level of the platform of the main-deck, which level coincides with the upper limit of this white streak, this part being thus painted to prevent its being fired at, lest, if penetrated so near the water, the ship herself should be endangered. As it was intended not to fire into the ports generally, the white paint was also extended from the main-deck level up to the gunwale, of a width to cover and protect each port, and thus the vessel became painted off into so many black spaces between the ports, each of which was made to present a separate target, capable of being used for any separate sort of missile; a white bull's-eye and a number being given to each target.

1st shot, cast-iron, cylindrical, 12-lb. charge.—Struck the upper part of No. 1 target a little to the right of the centre line of the bull's-eye, breaking away part of the plate and exposing the wood.

2nd shot, same description.—Struck to the left of No. 1 target, gouging out a small piece of the top edge of the plate.

3rd shot, same description.—Struck a little to the left of where No. 1 had struck, breaking away the plate and exposing the wood.

4th shot, same description.—Struck a little to the right of No. 3, and again broke away the plate. The part broken away by shots 1, 3, and 4 extended 3 feet 2 inches in length, by 12¾ inches in depth. All the bolts in the plate slightly started.

The above four shots were 80-pounders; and striking, as three of them did, diameter by diameter, close together on the edge of the plate, the destruction of the side they effected was seen to be very great, and such as must eventually cut the ship down to the water if continued; but it was equally recognized that in practice no such firing could be expected. One-half of the timber-thickness of the side was destroyed; but no shot lodged, and all went to pieces, the breaking-up of the shot together with the parts of the plate producing a vivid flame at the instant of impact similar to the explosion of a shell.

5th shot, same description.—Struck fair just over the bull's-eye of No. 2 target. Bulge of plate, 1½ inch; penetration, 1½ inch; total, 2¾ inches. All the bolts in the plate slightly started. Shot went to pieces.

On the firing of this shot the boat was manned for examination, everybody believing the ship to have been completely penetrated; and most of the glasses, my own among the number, proposing to see into her through the hole. "It has not penetrated at all," was the exclamation of surprise which escaped from the Builder of the gun himself when within about 10 yards of the side, and when our senses resumed sway over our imaginations. It was not easy to trace the effect of this shot on the interior of the ship's side; and on returning to the Gun-boat, our glasses were found to tell us quite faithfully that there was no hole.

In recording the effects of each shot, it will be observed that the

"bulge" of the plate around the point of impact is measured separately from the "cup" produced by the impact itself. I will here also state, once for all, that in almost all cases bolts were recorded, at the time, as having been started more or less extensively in every plate struck, which appears to have led to a requirement, a few days after the trials ceased, for a closer examination to be made on this point, when it was found that, except in the case of bolts actually struck, or in parts where the plate itself was broken up, no bolts had in reality been started at all, the whitewash around their nuts on the inside not being even cracked; their projection externally therefore arose from the timber of the ship having shrunk since the ship had been so hastily built, and the shots simply drove the plates home to their backing. This likewise accounted for the "springing" of several of the plates when struck on these trials, as well as on the previous one with the 32-pounder, and also for the "bulge" around the point of impact: and thus it became evident that the resistance of the side would have been still more complete, even than it was, if, instead of lying loose over the timber, the armour had been in close contact with it, like the bark on the body of the tree. After verifying the effects on the plates, no more cast-iron shot were fired from this range.

6th shot, puddled steel, cylindrical, 88 lbs.—Fired at No. 5 target, ricocheted, and struck on its side about 9 inches below the port-sill between targets 5 and 6, breaking the edge of the plate, and passing in a slanting direction to an upper-deck beam which it wounded severely. Plate broken and forced into the timber at the edge of the port-sill, $5\frac{5}{8}$ inches. The shot was picked up, broken into several pieces, on the main-deck.

7th shot, puddled steel, cylindrical, 89 lbs.—Fired too high, and passed through the steam pipe and funnel, 4ft. 4in. above the deck.

It is right to observe of the apparent irregularity of the fire, that the gun had never been sighted for elevation, and there was some motion in the Gun-boat. The Gunner was a first-rate practical "shot."

8th shot, homogeneous metal, cylindrical, 77 lbs.—Struck the bull's eye of No. 6. Bulge of plate, $1\frac{3}{8}$ inch; penetration, $1\frac{3}{8}$ inch; total, $3\frac{1}{4}$ inches. The plate was cracked around the point of impact in three places. Shot went to pieces.

9th shot, homogeneous metal, cylindrical, 78 lbs.—Went through the lower half-port between targets 5 and 6, carrying away in its course the fresh-water tank and pump, likewise an iron stanchion struck on its edge measuring 6 inches by 2 inches, and passing into the timbering of the Port side of the ship, started out one of the armour-plates $1\frac{1}{4}$ inch at one end.

This shot is one of the specimens on the table, as is the part of the stanchion cut away by it. It will be seen that the resistance of this stanchion, besides strongly marking the point of impact, was sufficient to split the shot, the split being subsequently filled up by the wood of the side.

10th shot, homogeneous metal, cylindrical, 78 lbs.—Struck over the centre line of No. 5 target at the joint of the plate, which it broke throughout its whole depth; the portion before the shot being forced in, and the wood shattered to a depth of $17\frac{1}{2}$ inches. This shot was found lodged in the water-way of the upper deck, and so hot that it had to be slung in order to be lifted out. It was set up from $9\frac{5}{8}$ inches to $8\frac{1}{4}$ inches, or $1\frac{3}{8}$ inch.

The larger of the two separate bolts on the table was taken out of the debris caused by this shot, as was also the circular fragment, which was found close surrounding the shot. All attempts to penetrate the ship's

side at the above distance of 400 yards having proved thus far fruitless, it was determined to reduce the range to 200 yards; but, on account of the lateness of the day, the further trial was deferred till the morrow.

We now come to the shot of the second day, marked red, the distance being 200 yards, and the gun-boat moored as before, so as to deliver her fire at right angles:—

1st shot, cast iron, cono-cylindrical, 100 lbs.—Struck on the line of main-deck platform, in the centre line of No. 6 target and near the centre of the plate. Bulge of plate, 1 inch; penetration, $1\frac{1}{8}$ inch; total, $2\frac{1}{8}$ inch. Plate started out at the foremost butt joint $\frac{1}{2}$ inch; the shot went to pieces.

As this shot struck the ship on the forbidden white line, close to the water, it was necessary to examine its effect; but, after the closest search, it was impracticable to find, by leak, or by any other indication on the inside, the spot where the shot had struck—a circumstance which I attribute to the solidity of the ship's construction at that part, and which has therefore a very practical bearing on the combined resistance of the side, as depending on the soundness and substance of the timber perhaps as much as on that of the plates.

2nd shot, cast iron, cono-cylindrical, 100 lbs.—Struck the left-hand corner of No. 6 target near the top. Bulge of plate, $2\frac{3}{8}$ inches; penetration, $1\frac{1}{2}$ inch; total, $4\frac{3}{8}$. Fractured the plate through its whole depth in a line with the angle of the port next abaft the blow. Three bolts around the point of impact projected $1\frac{1}{4}$ inch through the plate; but the bolts themselves were not started. Shot did not lodge.

3rd shot, homogeneous metal, cylindrical, 80 lbs.; length, $9\frac{3}{4}$ inches.—Struck to the right and over the bull's eye of No. 7 target, entering the joint between the plates until the base of the shot arrived at their inner side, where it stuck fast in the timbers. About one-third of this shot struck the plate above the joint, and two-thirds the plate below it; the upper plate, yielding in the line of least resistance, opened at the joint $\frac{3}{4}$ of an inch.

The shorter bolt of those specimens on the table was struck by this shot, which followed the bolt as it were, and exhibited on its own surface a projection of near half an inch where it had entered the bolt-hole. But I will here draw attention to the effects of impact on all the bolts exhibited, as having an important bearing on this mode of fastening armour plates. It will be seen that the swell or "set up" of the bolt when struck does not take place in the coned head which has been driven with force into the corresponding bolt-hole of the plate itself; but it takes place in the part of the bolt in the timber beyond the plate, and the swell or "set up" thus acts to harden the hold of the bolt in the timber. This appears to account for only one instance having occurred in which a bolt was detached, so as in any way to represent a splinter, which took place in the case of the 10th shot of the first day, the bolt in question, however, being driven over the deck, only a little beyond other portions of the debris of the plate. The fixing of armour plates by "bolting" does not thus appear to be attended with such serious results in respect to splinters as was at one time anticipated from their liability to be struck by shot.

4th shot, homogeneous metal, cylindrical, 80 lbs.—Struck 2 inches to the left, and the same distance above No. 3 shot. The centre of the shot, coinciding with the open joint between the plates, passed through both them and the ship's side, tearing away one of the iron knees on the main deck, and forcing a piece of the outer plating into the waterway on the opposite side of the deck to a depth of 4 inches; the shot itself being picked up on the deck near to where it had passed through.

As the diameter of the shot was 6 inches, by thus striking fairly on the open joint, 4½ square inches, or one-seventh of its area, encountered no resistance whatever from the armour plates; while the timber inside the plates had been already shattered by its predecessor. Yet, after entering the ship, its force was so spent that it went no further than it might have been pitched by hand, the single serious splinter thrown by this shot being the only instance throughout the two-days' firing in which the side of the "Trusty" failed to afford the most complete protection to all who might have been behind it; and the peculiar and exceptional circumstances of this single instance afford, perhaps, a more accurate measure of the practical impenetrability of such sides than is shown in the many cases where the shot were more completely rejected.

5th shot, soft homogeneous metal, cylindrical, 100 lbs.; length, 12¼ inches.—Struck over and to the right of the bull's eye of No. 8 target, forcing in a piece of the plate, 19 inches long by 17 inches deep, to a depth of 8½ inches. The plate cracked in various places around the fracture; two inside planks were broken, and one of the plate-bolts driven in 8½ inches. Shot did not lodge.

6th shot, hard homogeneous metal, cylindrical, 100 lbs.; length as before.—Struck the right-hand lower corner of No. 4 target.—Plate cracked in four places—14, 9, 7 and 4½ inches in length respectively. Bulge, 1¾ inch; penetration, 2¾; total, 4½ inches. Shot did not lodge.

On searching for the effects of this shot on the inside, its position was only discovered by observing that the fragments of whitewash, detached from the side to a distance on the deck of about 2 feet, took in one place the form of a cone, the apex of which was found to correspond with the point of impact outside.

7th shot, soft homogeneous metal, cylindrical, 100 lbs.—Fired at the open port between Nos. 6 and 7 targets, but passed over the deck and cut through an upper-deck stanchion on the port side.

8th shot, soft homogeneous metal, cylindrical, 100 lbs.—Fired at the same open port as before, but struck a little to the right of the bull's eye of No. 6 target, and drove in a piece of plate, 17½ inches long by 13½ inches deep, to a depth of 12½ inches. The inside planking was much broken, and forced in 3½ inches; one fastening bolt of the timber driven in 8 inches, and one of the plate-bolts 6½ inches. Shot did not lodge.

This shot and the fifth occasioned the two most serious instances of injury to the interior woodwork of the ship's side; but in both cases there was reason to believe that the shots had found out unsound portions of the timber.

9th shot, cast iron, cylindrical, 89 lbs.—Entered the open port before fired at, and went out through the ship's side abaft the opposite port, knocking away a piece of the plate, 3 feet by 2 feet 6½ inches, by 2 feet 9 inches; the remaining part of the plate being so entirely undisturbed that not a crack could be found in the paint at its joints with either of the plates above and below it.

It will be seen that this shot struck the very same *corresponding* plate on the Port side, and within a few inches of the same spot where the plate on the Starboard side had been struck by the shot previous; there being 11 lbs. difference in the weight of shot in favour of the first of the two, besides the superior quality of its metal; and yet in the one case the resistance of the side was so complete, that the superior shot could not find lodgement, while the inferior shot not only passed entirely through the side, but sent about one-third of a whole plate spinning high up into the air.

I believe that few experiments, even if arranged for the purpose, could afford more conclusive proof than is here presented of the totally different powers of protection afforded by a 25-inch oak scantling when backing a 4-inch plate from behind, and the same scantling when interposed in front of the same plate, and protecting it against the effects of even a less powerful impact. I perfectly agree, in the abstract, with those who deem it desirable to do away with timber backing, or even any timber combination whatever, in the sides of "Iron-cased Ships," but any close examination of the facts presented by the firings at the "Trusty,"—and I regard those firings as the only true or safe experiments yet made—will, I believe, go to show most conclusively that the efficiency of armour plating is, as it were, a function of the efficiency of the timbering which backs it, any want of such efficiency in the wood, as well as the iron, being equally prejudicial to the protection of the combined side. If this view, therefore, be correct, it follows that any departure from our present practice of combination, *which may be adopted without the sanction and proof of true and unmistakeable experiment*, would have to be regarded as a rash and hazardous tampering with a most serious matter.

The piece of plate driven off by this shot is represented in illustration (C); and on close inspection of the wood-work, it was found, that of the nine bolts concerned in holding it, four only, instead of all nine, were screw-bolts, of which three were broken where the fracture took place, and one was "drawn" unbroken; three "driven" bolts were also drawn unbroken, and two "clenched" bolts were broken; what additional support the plate would have had against being "driven off," had all the bolts been, as they ought to have been, "screw-bolts," and had their nuts inside grasped the plating of a complete iron ship, as in all our "Iron-cased Ships," true experiment again alone can tell us.

The fracture of this thick plate was throughout as crystalline as if it had never been of fibrous iron at all, and its instant release from the line of fracture, as evidenced by not a crack of the paint appearing at the joints of the portion remaining behind, shows that the separation must have been of a nature as undisturbing as if the one portion had never been connected with the other; and it has long been thought that we here have, on a large scale, the same phenomenon which was presented sixteen years ago at Woolwich, when it was first found that a shot would cut a circular disc of it own size out of a tough wrought-iron plate, leaving the residue of the plate as if no shot had ever been near it, but turning the disc itself into a condition as brittle as glass. The fragment of the iron stanchion cut away by the No. 9 blue shot, presents at one end a similar crystalline fracture; as do several of the fragments on the table, although in some the fibrous structure is no doubt most clear. I am, however, led to believe, that some peculiar change in the condition of fibrous iron does ensue, at least in some cases, from the impacts of shot,—as evidenced by the vivid flame before spoken of,—and should this be the case, its verification may have important bearings on our position in that iron age which we can now no longer ignore having come upon us; and I thus point to it as another subject worthy of consideration for true and searching experiment.

10th shot, homogeneous hard metal, cylindrical, 80 lbs.—Fired at an angle of 50° from the line of keel, but went too high and passed through the bulwark of the Port bow.

11th shot, marked in bright red; intended for observation on the effects of oblique fire; homogeneous hard metal, cylindrical, 80lbs.—Fired at the same angle as before. Struck close to the edge of the plate over the port between Nos. 7 and 8 targets, gouging out a piece of the plate 10 inches long by 1½ inch deep at the centre of penetration, and producing a crack on each side of the groove. This shot and the one previous were delivered from the Gun-boat under-weigh, at a distance of about 80 yards.

It was at one time proposed to try the effect of shells; but, as the side had proved so completely impenetrable to the best efforts of the heaviest and hardest shot, the purpose was given up as futile; and with the above 11th shot of the second day, the "Trusty" was released from further proof by Sir William Armstrong's first 80-pounder gun; and I at once pass on to the similar proof by the similar gun of Mr. Whitworth, which again took place off Shoeburyness in June last, the gun being embarked, as before, on a Gun-boat.

I may here say that from this latter experiment I was most unintentionally absent, but that all the effects of the firing were personally examined and measured afterwards, with the same carefulness as in the two former cases. The position for firing was at right angles to the side, as before, and the distance 200 yards, as on the last day of Sir William Armstrong's trials. The charge for the first shot was 12 lbs, that of the three subsequent ones 13 lbs.; diameter of shot 5 inches. The illustration (D) exhibits this firing, which took place against the port side of the vessel, the ports being filled in, and the filling supported by shores against the combings.

1st shot, homogeneous hard metal, flat-headed, hexagonal, 79lbs.—Struck the joint between the upper and second row of plates, taking 5 inches out of the upper, and 2½ inches out of the lower plate. The upper plate above the hole was cracked, and more or less started at the joints throughout. The shot lodged in the timbers about 11 inches inside the inner surface of the plate, and was subsequently cut out whole.

2nd shot, homogeneous hard metal, and in all particulars the same as before.—Struck 3½ inches below the upper edge of the same second-row plate as had been struck by the previous shot, and 22 inches distant from it. Fractured the portion of the plate above it to a length of 16 inches, starting it more or less throughout its joints or edges. After carrying away the centre part of an iron main-deck knee, this shot entered the ship, crossing about half-way to the opposite side of the deck. Close beside it lay a portion of the plate which it had punched out, and which still contained in it the entire length of one of the fastening bolts. This fragment shows the plate itself to have been unsound, and the 7-inch inner lining where the shot entered could be crumbled into dust from decay, of which the timbers also gave evidence.

The shot itself, with the remarkable fragment cut out by it, are on the table, and, together with the other fragments of the plate, show its indubitable unsoundness; and this, when taken in connexion with the rotten state of the backing, requires that the penetration of the side on this occasion should be regarded as quite exceptional.

3rd shot, of the same description as before.—Struck near the foremost edge of the small lower filling plate of No. 3 port, which it canted on one side and pierced, entering the ship and carrying away the chain cable at the bitts; it then struck heavily on the opposite side of the ship and fell on the deck.

In no sense can the loose fir blocks which filled this and the other ports, and the small plates which covered them, be regarded as representing, or intended to represent, the strength or structure of the "Trusty's" side, and I therefore regard this shot in every way as a mere "waster."

4th shot, same description.—Struck above a port near the upper edge of an upper plate, which it pierced, cracking the parts above it, as also at a distance of about two feet

to the left, over the centre of the port; the plate was also started at the joint-edges more or less throughout. The upper deck water-way was destroyed or disturbed to a depth of 18 inches from the inside of the plate, but the shot itself did not penetrate its own length, but its base projected two inches outside the plate.

This was the completion of the trial; and it is much to be regretted, for many reasons, that this practice with Mr. Whitworth's gun was so very limited; but for so much as we have of it, it presents no features of difference from the two former trials, as to the main conclusion of the practical impenetrability of the "Trusty's" side; and taken together with those former results, it proves, beyond a cavil, that the protection afforded by such sides against all guns as yet brought against them is practicably so complete, as to render ships thus defended most formidable antagonists to every unarmoured ship of whatever force; and if the "Iron-cased Ship" possess the sufficient superiority of speed to enable her to maintain her own safest distance for action, all wooden opponents must almost be placed at her mercy. But, while thus speaking of the results of those two most formidable specimens of rifled ordnance which as yet have taken rank as practical artillery, it seems almost more than wonderful, in a matter concerning the threatened security of our Empire, that nothing can be referred to in conclusive evidence of the powers of the gun we have all so long known, and used, and which is so confidently boasted of as capable of doing all which the rifled gun has been foiled at. In that confidence I have not myself the slightest share at present, and for these reasons. The spherical form of shot is the most unmechanical one which can be adopted for purposes of difficult penetration, its progress being arrested at each line of advance, up to the semi-diameter, by progressive increments of resistance, laterally as well as in front, imposed by the necessity for its advance being accompanied by a maximum of displacement, in every direction, of the substance to be penetrated. And for purposes of "smashing," as it is termed, the same form for other reasons is again equally defective. The entire force of impact falls on one point which thus alone receives the first arrest, while the surrounding portion of the mass retaining its entire momentum, necessarily separates away from that portion which has relatively lost it; and the entire momentum itself thus becomes a mere aggregate of the separate, though apparently simultaneous, impacts of the several fragments. Thus we have seen that the amount of arrest presented by a $\frac{5}{8}$-plate invariably produces this destruction of the ordinary spherical shot, and that even a $\frac{1}{2}$ or half-inch plate, produces it partially, while a 20-feet thickness of timber will cause no effect of the sort whatever; so completely does the penetration of iron present conditions peculiarly its own. Again, if there be any relation in such cases between the resistance offered, and the areas of impact of the substance offering it, then the spherical shot here also presents conditions of manifest inferiority. Thus, the momentum of Mr. Whitworth's 5-inch shot was concentred on an area of 19 square inches, and that of Sir William Armstrong's 6-inch shot, on an area of 28 square inches; but the momentum of the 8-inch solid 68-pounder will be dispersed over 50 square inches, or three times more surface than in the case of Mr. Whitworth's shot, and nearly twice as much as in that of Sir William Armstrong's; and any one who will but glance at the diagram before us, will see that even the loose 4-inch plates on the

sides of the "Trusty,"—let alone the combined side itself,—have never yet been penetrated, except where the immediate vicinity of a joint has offered a "line of least resistance." The solid shot 95-cwt. gun at 200 yards, may also fracture the plates near their edges, no doubt; but if it penetrate the "Trusty's" side with any sort of shot it can throw, or even if it fairly "lodge" a shot "in" the side, after penetrating any plate at a point of impact one foot distant from the nearest edge, the plate and timber being sound and in close contact, it will prove itself in such matters a far more powerful gun than I intend believing it to be until it has given this proof. Why a question of such simple solution has been left so long undecided, to perplex and mystify so many, appears almost marvellous, unless it be for the purpose of promoting and supporting discordant views in a matter where the most combined efforts of all can scarcely replace us in that position which prolonged discords in counsel have already lost for us.

The question of "oblique fire" is one of degree only, all fire of all ships, the one at the other, being necessarily more or less oblique. In all engagements between ships of wood, this "oblique fire" has always been a mutual object with both parties, as being the next most destructive to that of a "raking fire," to which it is alone inferior in its effects of sweeping an enemy's decks; and so long as our "Iron-cased Ships" continue to be semi-"Simooms," presenting complete penetrability for one quarter their entire length forward, and one quarter aft, they must be prepared to meet, if it can be inflicted on them, with the same "oblique" practice too.

Thus, in distance, in deliberation of fire, in choice of position, in the most studied selection of material for shot, and under fire of the most powerful known guns, the perfectly passive proof sustained by the "Trusty" has given to the "offensive" principle every possible advantage; with the result—in this only instance of conclusive firing at a ship built purposely to be so fired at—that in three days' trials, and, barring the case of unsound wood and iron at Mr. Whitworth's second shot,—one spent shot, and one serious splinter, have alone penetrated the side, and that under obviously exceptional circumstances.

But apart from this all but unviolated protection afforded by the combined side, the plates by themselves may justly shout their triumph. They are vertical; they are loose on their backing; they are comparatively small; they are but four inches thick; yet it will be seen by the diagram that every shot which has seriously fractured them has struck within six inches of an edge; the few which have lodged have struck close to an edge; and those which have struck at a greater distance than six inches have produced indentations only, with scarcely one serious crack; so that to double the size, not thickness, of plates, is at once to halve their liability to casualties; and even as it is, there remains in the plates alone, if well set home on their 25-inch backing, an unexpended amount of resistance to actual penetration which challenges the powers of any present practical gun.—So much once more for the difference of results between *true* experiments and *sham* ones; between impacts on the true 1,700-ton "anvil," and those on its sham and very "cheap" representative of 30 tons only.

I am bound, in courtesy and respect, to reply to the personal appeal made to me in page 32 of Sir Howard Douglas's recent "Postscript," and, if only for novelty's sake, it would give me sincere pleasure could I agree

with him. But in truth there can be no such thing in ship-firing as that of delivering shot after shot at the same spot, until—like the fixed and unopposed gun in the breaching battery—the opponent object is pierced. There was no intentional dispersion of the fire against the "Trusty's" side, and the exceptional case of two shots striking within two inches of each other was perfectly free to have repeated itself as often as it could. But by the kindness of Mr. Josiah Jones, I am able to put before you a diagram of the firing at his angulated target in August last; and I could wish that the patriotic spirit which led that Gentleman to supply the means of so costly an experiment at his own expense—and this on its scale "was" a true experiment—had met with a higher recognition of public merit than as yet it has done. In this case the object truly was, and very properly so, to test the principle up "to the point of breaching;" but a glance will show that even the chosen smooth water of Portsmouth Harbour, with the highest practical gunnery, renders shot after shot on the same point purely accidental; as in thirty-three shots at 200 yards only five have touched a previous point of impact.

The cases of partial exception alluded to early in the evening, as to firing at real vessels built, like the "Trusty," purposely to repel the effects of the heaviest shot, are those which are stated in Articles 400 and 401 of Sir Howard Douglas's "Naval Gunnery;" but at what date the trials took place we are not told. In the one case three shot appear to have been fired at the "Erebus," a sister "battery" to the "Trusty," with this important difference: that, in her structure, reliance seems to have been placed chiefly on the support to be given to the armour by the interior iron, or "Simoom," sides, which were protected, or padded, as in the case of the "Terror," "Thunderbolt," and the rest of the class, by 4½ inches only of teak timber beneath the exterior plates; and the effect of the second 68-pounder shot, in "ripping up" this "inner lining," and "bilging in the ship's side to the extent of 1½ inch," bears the further valuable and important testimony of another true practical experiment as to the essential condition for effective protection in a sufficient timber support, as Sir Howard himself also enforces in the sixth "Conclusion" of his "Postscript."

The "Meteor" referred to in Article 401 is a true sister to the "Trusty," and, if not more unsound in wood, and with equally good armour, must, it is to be presumed, have presented the same conditions of impenetrability as the sides of the "Trusty" herself did. But, beyond the fact that some 32-pound shot, and one 68-pounder of cast iron, and two of wrought, together with a 68-pounder shell, were fired at her at ranges of from 400 to 300 yards, I find it difficult to ascertain what really did occur, or whether anything of an important nature occurred at all; and, from the context, I am led to infer that the piece of plate, 15 inches by 9, described to have been "driven inside the ship" was driven into the timber only, and not in reality through the ship's side. The vagueness of the description, therefore, as well as the very partial extent of this trial, have precluded my doing more than thus recognizing its existence, to which, as a "true experiment," so far as it went, it is, like its predecessor, fully entitled.

As Mr. Whitworth has so kindly contributed to the illustrations of these

Lectures, and as the performance of his Gun,—every shot from which, it will be observed, was fairly *lodged* in the "Trusty's" side, though its *penetration* of that side was exceptional,—has been a prominent feature of the subject, it will, I am sure, give great pleasure to all present to know that the cause of recent accident to the gun has been correctly ascertained by our great National Mechanician, and is in no wise connected with either the principle or construction of the piece which it has ruined. It was occasioned by "air-space" between the charge and the shot—a cause of danger which every sportsman knows he has to guard against, but which few could have suspected powerful enough to endanger a barrel of such strength. But, by careful—and, in this case, I need not add "true"—experiment, Mr. Whitworth has ascertained his ability to burst or bulge the barrel of any gun at any desired point by the intervention of "air-space." And there are on the table before us two barrels of his hexagonal rifles, both of which have been so bulged in their strongest parts—one of them in two places—and which have been kindly lent for illustration of this remarkable fact. His gun itself had been firing at angles of depression immediately before the injury was discovered; and, from the looseness of the shot in the barrel, due to the windage given to it; notwithstanding its "mechanical fit;" it must have left the charge before firing, no wad having hitherto been thought necessary. The mode of loading our ordinary guns, and the chambered form of Sir William Armstrong's gun, will sufficiently account for the practical discovery of the very important nature of "air-space" having been first elicited by this accident to Mr. Whitworth's 80-pounder gun. The chief injury was found to have taken place internally, at a spot a short distance in front of the charge, and to which the shot when the gun was depressed must have travelled; from this spot the fine crack through the core of the barrel was found to extend, not in front towards the muzzle, but back towards the breech.

Mr. GREENER, of Birmingham.—Having been, I believe, the very first man that experimented upon the perforation of iron plates, I trust I may be permitted to offer one or two observations. My experiments commenced as early as the year 1825, owing to an accidental circumstance. Boy-like, after shooting at a target, I hung up a butcher's cleaver and amused myself by firing at it; the consequence was I found it perforated. I was subsequently induced to carry out similar experiments, and eventually I succeeded in perforating an inch plate with a 2-ounce leaden bullet. Therefore, having paid some attention to the subject, I think I am qualified to speak upon this occasion. In the first place, I regret that experiments have not been made, and that we did not enter upon this discussion, some twenty years ago, because our knowledge of gunnery would then have been very much in advance of what it is at the present moment. With regard to the experiments which Captain Halsted has brought under our notice, they appear to me for any beneficial purpose perfectly futile. Many years ago I was induced by an officer to try experiments with an iron bullet; he tried to persuade me that the iron bullet would perforate a plate as well as a leaden one. I nearly lost my life in consequence, for the bullet rebounded and nearly struck my face. Now, the futility of these experiments is, that the iron bullet strikes the plate with only half its force, the other half being expended in effecting the rebound. Suppose the iron bullet to possess a force of 10,000 lbs.; in reality only a force of 5,000 lbs. is given in the impact, upon the side of the plate. You find an illustration of this in the rebound of a hammer when struck upon an anvil. If you were to strike an anvil with a piece of lead, the lead would remain there; it imparts every particle of its force. Therefore, if a leaden bullet contains a force of 10,000 lbs. it would strike the vessel with the whole of that force. These experiments, therefore, amount to

nothing. Cast-iron will not penetrate iron. Steel is more inelastic and more likely to penetrate. But the soft iron bullet of Sir William Armstrong is the most likely to do it, though that is perfectly useless for the purpose he intended it. I have watched these experiments, and have known all that Captain Halsted has done. I have had it reported to me that nine months ago, in the case of Armstrong's shots being fired against the "Trusty," the splinters nearly decapitated a boat's crew. The law with reference to iron penetrating iron must be plain; we need not go further into it. Again, to show the inutility of these experiments, let me mention that if you place an iron target two yards from the muzzle of a gun the shot will have no effect, at ten yards no effect, at fifteen yards no effect, at twenty yards a little effect, but at twenty-five and up to thirty and thirty-five yards the shot will go right through the plate. Now the whole of the experiments with the "Trusty" were made at too short a distance; two hundred yards with 100-pound shot does not come within the proportions I have given. You can try the experiment at any time with an ordinary rifle. There is another objection I take, and that is to the very thing which Captain Halsted has recommended—the elongated bullet. My experiments show that spherical bullets will perforate iron better than taper ones: I tried it only five or six days ago. Therefore, the material being unsuited, and the distance also unsuited, I hold that these experiments on the "Trusty" are perfectly useless. I am so confident upon this subject that I would stake almost every thing I possess that a first-rate man-of-war would, with leaden projectiles tempered by Mr. Whitworth's process, destroy the "Warrior," or any other iron-clad ship you might choose to bring against it, in a very short time. With respect to leaden projectiles of a large size, I am aware of the mechanical difficulty that exists to their use, viz. that, if perfectly soft, they would squash up in the gun. But Mr. Whitworth has taught us there is an advantage in tempering lead; hence the advantage which his rifle has over the Enfield: the Enfield soft leaden bullet would not penetrate the same number of deals that a Whitworth would. Therefore, give me tempered leaden bullets, and give me a 100-gun ship with 10-inch guns, and I say they will destroy your new iron-clad ships. That I am certain of, from the experiments I have made. There is no elasticity in lead; every ounce of force it contains is imparted to the object struck; the velocity too is great; and there is the additional effect that it has a greater specific gravity. The leaden bullet having these advantages, it becomes a great question whether it ought not to be adopted. Having been, as I tell you, the originator of the system of elongated projectiles, I doubt very much their application to the destruction of wooden vessels. I have noticed many of the holes left after the perforation by Sir William Armstrong's shots, and I have found you could almost plug them with a marlin-spike. From their peculiar form they do not cause splinters; they go like a knife, press the wood away on each side, and pass through. I am the advocate of rifled guns, but I certainly do not think they are calculated to destroy a wooden ship so soon; and I think our wooden ships would be quite a match for the "Warrior," or any other vessel of that kind.

Mr. SCOTT RUSSELL.—May I request the gentleman to explain how it is possible that a missile of a given weight, because it is elastic, has to lose half that weight? I never heard of such a thing in mechanics. I do not understand how it is possible.

Mr. GREENER.—The very fact of its rebounding back is a proof to you.

Mr. SCOTT RUSSELL.—It does not rebound back until it has given its whole weight.

A MEMBER.—If it takes a force to stop a ball, it takes twice that force first to stop it and then to send it back again.

Mr. SCOTT RUSSELL.—It is a law of mechanics that the blow of an elastic body is just double that of a non-elastic body.

Mr. GREENER.—If you try it you will find it is as I have stated. You will find you cannot penetrate a boiler-plate with an iron bullet where you can with a leaden one.

Mr. SCOTT RUSSELL.—I do not doubt the fact that a leaden bullet will penetrate more easily than an iron bullet; I doubt the reason given for it.

Mr. LAWRENCE.—If there be any doubt about it, surely such an experiment as that ought to have been made before this time. It could easily have been made thousands of times. There is on the table a shot which has all the requisite conditions. Several times attempts have been made to get it experimented upon, but, by some very strange chance or other, that has not been done.

Mr. GREENER.—The anvil has been instanced; surely, the harder you strike it the higher the hammer will jump. But the second blow does not require the same force downwards; it assists itself. It is a plain mechanical fact.

Mr. SAMUDA.—We should better understand what that gentleman means if he were to

describe to us a simple experiment which he has actually seen or can verify—describe to us the greatest thickness of plate which with a particular size of leaden bullet he has seen penetrated, and the greatest thickness of plate which he has seen penetrated with a corresponding bullet in iron—leaving us to draw the deductions.

Mr. GREENER.—In my work of 1847 you will find a series of experiments carrying the penetration up to an inch thickness of plate, with a 2-ounce weight ball, with something like 13 to 14 drachms of gunpowder; but I have never succeeded in penetrating iron with iron, tried equally under the same circumstances. The first time I tried with iron the ball came back to my head. The experiments were made with iron bullets of the same weight and of the same shape. They were all spherical bullets.

Mr. SAMUDA.—Do I understand you that a 100-pound leaden ball will penetrate with more facility than an iron or a steel ball of 100 lbs.?

Mr. GREENER.—Most assuredly. I have no doubt about it.

Mr. SAMUDA.—That is an opinion. What is the weight of an ordinary Enfield rifle-bullet?

Mr. GREENER.—An ounce and so many grains.

Mr. SAMUDA.—You are aware probably that the Enfield bullet at 100 yards will not penetrate five-sixteenths of an inch of iron.

Mr. GREENER.—It depends upon what weight of powder you put behind it.

Mr. SAMUDA.—I am speaking of the ordinary Government charge, two and a quarter drachms of powder, firing an ordinary Enfield rifle against a target.

Mr. GREENER.—I agree with you, it will not; and I tell you a spherical bullet will do it much more effectually.

Mr. SCOTT RUSSELL.—Will you allow me to try and disentangle the question of where we are talking about facts, and where we are talking about opinions? So far as I have noticed the facts, they are these: that a leaden bullet under certain circumstances has penetrated an iron plate, which circumstances have extended up to a plate one inch in thickness. So far as I have heard, the facts end there. Now the facts here are of quite a different character. The facts here are that certain elongated missiles of very hard material have produced given effects upon plates four inches thick, and penetrated them. Now, if I am not mistaken, all that this gentleman states upon this subject is mere opinion. Then, if you please, we will end the matter here. The penetration we have seen of steel balls, of iron balls, and of cast-iron balls, is a question of 4-inch plates. The other is a question of round leaden balls on 1-inch plates. Permit me to say that the distinction between these two cases is far more important than it at first sight appears to be, because what is practicable on the small scale is probably in this case utterly impracticable on the large scale. That is to say, it is probably utterly impracticable to produce leaden missiles of that form, and to give to them that velocity. That, however, I give as a mere matter of opinion; therefore I would wish this meeting to carry away, as the true report of what has just passed here, that all we have been saying about the penetration of 4-inch plates by leaden bullets is entirely a matter of opinion, and not in the least a matter of fact.

Mr. GREENER.—You must clearly understand me. I do not mean to say that I have ever carried out an experiment of this sort—only Government can do that; I was merely reasoning from analysis. The same principle carried out on the large scale would be found to answer.

Mr. SCOTT RUSSELL.—Not at all. I beg leave to say that scale in this case is a principle.

Captain SULLIVAN.—We have heard a fact that is new to most of us, and I think we should receive it as an interesting one, which is really worthy of consideration, and not attempt to set it aside. If a small bullet will go through an inch plate, it is worthy of consideration whether a larger bullet will not go through a thicker plate. It has struck me as a new idea, and I should like to see it put to the proof; indeed, it is a point of such importance that I think it ought to be settled without delay.

Captain BLAKELY.—I think it so important that I shall put it to the proof next week.

Mr. ASTON.—With regard to iron bullets, or leaden bullets I believe a five-sixteenths of an inch plate will resist them. I have seen cast-steel bullets, or rather homogeneous bullets, which have gone through six-tenths of an inch of iron. Five-sixteenths will resist lead, and six-tenths have been penetrated by homogeneous iron. It is a fact, as I could show it; and Captain Halsted has seen the experiment made.

Captain LEATH.—There was another fact given, of which I think some explanation is required—that shots fired at a plate from a short distance do not produce the effect

which the same shots fired from a long distance do. That to my mind is a more extraordinary fact than the other is.

Mr. GREENER.—I believe in the experiments made at Chatham it was found that the penetrating power of the Enfield increases even up to 180 yards from the gun. I believe that is stated on authority. At any rate you will find it stated by Captain Jervis.

Mr. SAMUDA.—I have tried a great many experiments, but I have not found it so.

Mr. GREENER.—You will find it stated so. If you will allow me, I will give you another reason. You are aware that, in starting a charge from the breech of a gun, the great difficulty you have to contend with is to displace the column of air in the barrel. The bullet as it leaves the barrel has to displace all the air in the tube first, and it is quite clear that the weight of that column of air depends upon the length of the gun, and a condensation of many atmospheres; but, the moment the bullet is clear of the muzzle, it meets a decreased resistance, and thus increases its velocity from that point to an enormous extent.

Mr. SCOTT RUSSELL.—No. I have a course of the most accurate experiments on the Armstrong guns at all distances, and permit me to say that the moment the ball leaves the gun it loses velocity at every step in its progress.

Mr. ASTON.—I can quite confirm that with regard to experiments made with Mr. Whitworth's gun.

Mr. GREENER.—I am sorry to differ from you, but you will find from experiment that I am correct.

Captain Sir FREDERICK NICOLSON, Bart. R.N.—I should like to ask Mr. Scott Russell one question. Captain Halsted has mentioned a peculiarity respecting the iron-plate which I should like to have explained. He states that, upon the iron plates being struck by shot, they become as brittle as glass. Is that so?

Captain HALSTED.—Permit me to say that I must have made myself misunderstood. I said, not the plate, but the disc which is struck out of the plate—that which forms itself into the mass of splinter; not an alteration in the plate which is left, but an alteration in the part which is struck.

Mr. SCOTT RUSSELL.—I think that is a thing very hard to understand. We may all entertain an opinion upon the subject, but the only approximation to an explanation I can give you is this. It has been proved beyond all doubt, that the more iron is shattered and shaken, and the more its condition is left free and assisted by agitation, the more it returns to what you are aware is the native original condition of iron, namely, a high state of crystallisation. Fibrous iron is made by the artificial process of drawing, re-drawing, and rolling. The natural state of iron is a crystallised form. All agitation, and every process that leaves the iron free to obey its original force, brings it back to its original state of crystallisation. That is a fact. But what I am now going to say is a pure piece of imagination. I can quite imagine that, in the act of the separation of the disc from the surrounding plate, the particles of the iron are so suddenly released from all the tensile forces all around that keep them in their places, that, for the moment, the particles of iron are left free from one another, and surrounded by an intense atmosphere of caloric. I believe this, because you all know the intense heat produced by striking a violent blow with a hammer on an anvil. And Captain Halsted has mentioned to us that the heat in this concussion was so great that they saw a blaze of fire as the shot struck the plate. Now, if there was this blaze of fire, I ask you to imagine if you can—for it is only imagination—what the condition of each separate particle of iron was at that moment in a separated disc, and I think your imagination will help you to believe that the particles were left pretty free to return into what condition they pleased, and that they did then become altered in shape and assumed a crystallised form.

Sir F. NICOLSON.—May I ask whether you anticipate that, after a plate has been struck several times severely by shot, it will become permanently crystallised?

Mr. SCOTT RUSSELL.—The nearest answer to that is this. It is perfectly well known that, after plates of iron have been struck, their magnetic condition is altogether changed—that a highly magnetic state is induced. I need not say that that change of the magnetic state is a very analogous state to a change of crystalline forces.

Mr. LAWRENCE.—May I be allowed to say a few words? I think, from all we have heard, that nothing but an experiment made openly and properly, and fairly reported, will have any weight on matters of this kind. The moment a gentleman gives his own experience, privately attained, he is instantly met with by denials and doubts of all kinds. In a question of this great importance it is not at all possible that the opinion of an individual can have much weight. Indeed, I think it is altogether discreditable to us that an opinion

should be entertained upon this subject at all. Any opinion that is really valuable can only be based upon experiment, and no opinion ought to be entertained in matters which can be experimented upon. No science has ever been built up on mere opinions. Experiments which can be repeated easily, or can be explained in such a way that any man with ability is able to go over these experiments and follow them step by step, who can prove himself what he did not previously believe, those are the experiments on which science is built up. Do you suppose that on this, which is perhaps one of the rawest and barest matters that can possibly be imagined, considering its importance, the opinions of individuals can be considered worthy of any notice? The only two experiments we have had are those which took place on the "Trusty." Now, is it the fact that those two guns (the gun of Mr. Whitworth and the gun of Sir William Armstrong) are the only guns that have been made? Are theirs the only kinds of shot that have been made? Do other nations depend upon Mr. Whitworth or Sir William Armstrong? Do they not act for themselves? Who are the parties that we expect we shall get into collision with? I need not mention any nation, but it is quite evident that the guns which those nations adopt are the guns we ought to experiment upon, because those are the guns which are likely to affect our ships and fortifications, not the guns we adopt for ourselves. I myself have made some experiments in penetration, and I find that a particular kind of shot has very good penetrating effects. It is altogether different from the iron shot, but I have not been able to test it satisfactorily. I believe other nations have done so, and that they have adopted that particular form of shot. I cannot help thinking that it is much more to the interest of this country that those missiles which are likely to be used against us should be first tried by ourselves.

Mr. ASTON.—Will the gentleman tell us the shape of this shot?

Mr. LAWRENCE.—The shot is on the table. I shall be happy to explain it.

The CHAIRMAN.—Perhaps you will come forward and explain it. There is no doubt experiments ought to be made. It is reported that the Russians have perforated 4-inch plates at 2,000 yards. I do not know how far that is correct.

Captain BLAKELY.—And the French at 3,000 yards.

A MEMBER.—Was it a 4-inch plate?

Captain BLAKELY.—A 4-inch plate made in England, or a 4½.

The MEMBER.—May I ask the date? was it not on the 10th of October?

Captain BLAKELY.—My information was given me a week ago.

The CHAIRMAN.—It was reported by our military correspondent in France; it is officially reported by General Hamilton in Prussia.

Mr. SAMUDA.—I can only say that so far as the latest information I have received from France goes it is, that while speaking in terms of great contempt of the experiments which we make in this country compared with those which they make in theirs, they tell me they have not been able to penetrate any of their 4½-inch plates at all. So the information is very different from that which came only a week earlier.

Mr. SCOTT RUSSELL.—I have seen the experiments on their "Trusty," and I can say they very nearly coincide with our own, and that their plates are in no respect different from ours.

Mr. LAWRENCE proceeded to explain the construction of the shot to which he had directed attention. The shape is cylindrical, rounded at the head, and perfectly flat at the base. The shot measures 8½-inches long and 6½-inches across, and weighs 80 pounds It is composed of two metals, the base of lead and the head of zinc. This combination, it was stated, is for the purpose of protecting the zinc when it strikes against an object, the lead base giving way on the impact, and consequently the zinc, which is excessively brittle, is not injured by the blow. Mr. Lawrence added:—The first notion I had was that if these metals were soft it would be considered they were not equal in point of penetration to iron. I therefore endeavoured at once to make experiments for penetration. The first experiment which I made was at Woolwich in 1852 with small musket shots made of the metal. The shots penetrated much better than lead, and they passed through the wood without being altered in form. A subsequent trial I made with a 12lb. shot against oak 2 feet thick, backed by clay. That shot went through the 2 feet of oak without altering its form and penetrated 18 feet into the clay, which it dashed up to a greater height than the ceiling of this theatre. I tried a great many times to get the experiment repeated, and there was actually an attempt to fire at iron plates, but by some very strange accident they did not contrive to hit the target, though it was nearly 50 feet long and 12 feet high. At three attempts they did not hit the target. They fired with a 95cwt. rifled gun—rifled on my own system of rifling, a diagram of which I

sent to Woolwich in 1855. It was rifled at Woolwich under the superintendence of Colonel Wilmot, and the gun itself was made at the Low Moor Works. I mention the circumstance of their not striking the target for this reason. At the first experiment in 1856 they went within 1 yard at 4,000 yards, therefore I think it very extraordinary that at only a distance of 400 yards they should have missed a target of the size I have mentioned.

The CHAIRMAN.—Then the gun has never been fired?

Mr. LAWRENCE.—It has never been fired at an iron target.

The CHAIRMAN.—Nor any ball of smaller size?

Mr. LAWRENCE.—Yes, I have a ball in my pocket fired at an iron plate.

The CHAIRMAN.—What thickness of plate?

Mr. LAWRENCE.—A 3-inch plate. The shot was crushed up. This is a specimen of it. You can see the zinc in the interior and the lead on the exterior. That would go through wood without altering its form at all.

The CHAIRMAN.—But you do not know what thickness of plate it will perforate?

Mr. LAWRENCE.—I have not the least idea.

Mr. GREENER.—Was your experiment believed in by those who witnessed it as being good or effective with that shot?

Mr. LAWRENCE.—Yes, all the experiments were made by the Government officers, and I have their certificates.

Captain TYLER.—I do not know which we differ most in, our facts or our opinions; but I should be glad to say a word with reference to what Mr. Scott Russell has just stated—with all due deference to so great an authority. In answer to the question which Sir Frederick Nicolson asked him, he told us that artificial metal, such as rolled or hammered iron, was altered in quality and made brittle by all action upon it; that is to say, that by agitation it was re-made—returned into its original crystalline state. Mr. Scott Russell went on to say that he believed that changes in its magnetic condition might possibly have a great deal to do with such an alteration. I dare say a great many who are present saw those beautiful experiments of Dr. Scoresby, in which he took a poker and showed that when it was held in the line of the magnetic meridian a few taps in one direction or a few in the other would entirely reverse, over and over again, its magnetic condition. Those are facts. The magnetic condition was constantly reversed, without in any way altering the iron, either making it crystalline or making it fibrous. I do not suppose Mr. Scott Russell will tell me that two taps of that sort will alter the crystalline condition of that iron.

Mr. SCOTT RUSSELL.—I have an opinion. I think it would be slight in proportion to the slightness of the tap.

Captain BLAKELY.—I think Mr. Fairbairn's experiments have proved that a great number of slight taps will break the strongest piece of iron.

Captain TYLER.—But if the taps are infinitely slight they will not break a bar of iron.

Mr. SCOTT RUSSELL.—If they are infinitely slight it will take an infinite number to do it.

Captain TYLER.—We have iron that has undergone vibrations for a great number of years without appearing to have any alteration in its crystalline condition. I think the theory is put forward, to say the least, rather too strongly.

Mr. ASTON.—May I be permitted to make one or two remarks with regard to the thickness of plate that may be penetrated? Captain Halsted has stated that, in his opinion, the 4-inch plates have got the victory: that is to say, they have been able to resist projectiles hurled against them within distances which one may take to be too short for ordinary tactics in ordinary warfare. But I think Captain Halsted has scarcely taken into consideration that it is very possible and very probable that projectiles of still larger diameter will ere long be brought to act upon iron plates, such as at the present moment are fixed upon the sides of the "Warrior." It is a fact in mechanics, which I am sure many gentlemen here present will know a great deal more about than myself, that if you wish to punch a plate of a particular thickness, you should, to obtain the best result, employ a punch of a diameter at least equal to the thickness of the plate. If you wish then to punch a plate 4 inches in thickness, you must employ a projectile of at least 4 inches in diameter. Now, if a projectile $5\frac{1}{2}$ inches in diameter just finds enough to do in penetrating a plate $4\frac{1}{2}$ inches thick, that is, if the projectile, not only at 200 yards, but at 450 yards, will pierce through the plates, but is found in some cases (when the conditions are not favourable) to be resisted by the wood backing behind the plates, it is quite clear, I say, that we have then the balance pretty accurately struck; the power of penetration

of the 5½-inch shot, and the power of resistance of the 4½-inch plate are nearly equal. If projectiles of 5½-inches have met with their match in 4½-inch plates, we should then be justified in supposing that projectiles of 6 inches diameter would be more than a match for those plates. I do not say that as a matter of opinion; in mechanical operations it is found that a punch of a certain diameter will go through a certain thickness; and we find that in projectiles this principle has been borne out pretty nearly, inasmuch as a kind of balance is, upon Captain Halsted's account of the experiment, struck between the 4½-inch plate and the 5½-inch diameter.

Mr. SAMUDA.—In the subject we have before us to-night, the point we have to discuss is, mainly, what sort of plates we can have upon ships' sides to compete with the artillery which may be brought against them? Until within the last two months I held exactly the same opinion which the gentleman who has just sat down holds, and I argued from exactly the same point of view—that, as it required a punch to be of a diameter equal to the thickness of the plate you wanted to go through, which was the generally received opinion of engineers, accepted without observation, I thought we were perfectly safe with the present thickness of plate, and need not go any further. But to be quite certain that the argument would hold water (for at the time I was preparing a paper upon the subject), I thought I would try it; and I then found that that opinion which, in common with most members of our profession, I had imbibed, without taking any means to test it, was entirely erroneous. I found that a punch of a diameter only half the thickness of the plate was capable of penetrating it with the greatest possible ease. Not to make any mistake about the figures, I may tell you at once, I took a plate of an inch-and-a-half in thickness, and I punched a hole out of it three-quarters of an inch in diameter. The whole secret lies in this: formerly we added another condition, which condition was not an essential one, though we had always accepted it as essential, viz. that the punch must necessarily be somewhat longer than the plate you are going to put the hole through, yet it need not be. If you reduce the punch to half that depth, and to half the diameter, it will punch half the thickness of the plate; and then that half acts as a punch, and punches out the other. I am giving you a plain fact. No person was more deceived than I was myself.

The CHAIRMAN.—Before you leave that point, just let me ask you a question. Would a larger punch have done it more easily? That is an important point.

Mr. SAMUDA.—I do not know. The punch did it with ease. I looked at it, when I started, as an impossibility to punch a plate of an inch in thickness with a punch that was only half-in-inch in diameter.

The CHAIRMAN.—Of course the balance spoken of is not arrived at if your view is correct; still it is a very important question. If a larger punch will punch it more easily, it shows the value and importance of a larger sized shot.

Mr. SAMUDA.—Mr. Scott Russell would say it is a matter of opinion, but I have no doubt a larger punch would punch it more easily, because the proportions of the punch would be changed much more favourably. But the absolute proportions which we thought a punch ought to have to punch a plate, are found, when we come to get at the facts, to be totally done away with. When I made that experiment, I did it from having looked at the matter in this way. It appeared to me from the very experiments on the "Trusty," which Captain Halsted has spoken to, that the greatest effort of the 5-inch punch was exerted to get through these plates. Out of all the shots fired at the side of the ship only two had penetrated; and of those one only just penetrated the armour, and remained fixed in the wood at the back, while the other fell some 8 or 10 feet in the ship.

Captain HALSTED.—I was speaking of penetrating the ship. I have mentioned to-night that the whole four of Mr. Whitworth's shot lodged.

Mr. ASTON.—They all went through the plates, and two went through the ship's side as well.

Captain HALSTED.—They all lodged in the ship's side. They went through the skin of the elephant, but they did not enter his vitals.

Mr. SAMUDA.—Whether it was four or two that went through, they had so completely expended their force in going through that they would not have damaged any man standing on the other side of the ship.

Mr. ASTON.—Yes, they would. They entered fairly, scattering a shower of splinters that struck the other side. They drove a large iron bolt right through to the other side of the ship, I picked it up myself.

Mr. SAMUDA.—Then, the point that occurred to me in looking at that vessel is this: these shot appear as if they can be got through.

Captain HALSTED.—Not a single one of these met with the full resistance of a solid plate; they struck close upon the edge.

Mr. SAMUDA.—The one I noticed punched a perfectly clean hole through the plate, but, as I say, it remained lodged in the side of the ship, in the end of a beam. Well, having made this experiment with a punch, and having come to the conclusion that these shot would go through, I wanted to test in my own mind, as to whether these shot might be regarded as more formidable weapons to be brought against an iron-cased ship than a spherical shot. I confess I came to the conclusion that a spherical shot might in the long run be regarded as the more dangerous weapon. Because, wherever these shot would go through the ship, I looked upon it that they acted precisely as the punch we have been speaking of—that they punched a hole clean through the plate, that they destroyed the particular piece of plate which they had punched out, and left all the rest of the plate perfectly intact. It in fact represented nothing more than the holes punched in a boiler plate; and we all know that when that is done, the plate in the vicinity of the hole is not damaged. I looked upon it that that would be the effect produced when these shots had gone through; but that when the spherical shot had struck, although in the first instance it did not go through, a sufficient number of times in or near the same place, it separated the particles of iron so effectually from one another, that after a sufficient number of blows, I do not know how many, it damaged the plate over so large a space that it broke it, and formed the commencement of a breach which could afterwards be carried on very successfully. That does not take place with the elongated shot, I am not acquainted with any number of experiments that have been made in this country with spherical shot, but we have seen by what we have heard to-night, how little we can depend upon what we hear from abroad. There is, however, one piece of information I have got from abroad which, I think, I can place reliance upon, and that is with reference to some experiments made in Russia. There, I believe, they succeeded in breaking up 4-inch plates placed to represent the side of a ship, so far as a target would represent the side of a ship, 50 feet long and 6 feet high. After firing 250 shots at a distance of 400 yards from one of their guns carrying a 60 lb. shot, they made a complete and practical breach in it. But it took 250 shots to do it. Still I do not think the 250 shot going through the side of the ship, of the punching description, would have rendered that ship so accessible to the pouring in of larger shot and shell as 250 round shot if you could have got them in a sufficiently small space to have knocked out an opening between two of the ports. But, taking it in any way you will, I think it comes to this, that the capability of resistance has been so amply proved by the "Trusty" over and above everything that has hitherto been brought forward in the shape of a ship's side to resist any artillery, that the greatest possible attention ought to be fixed upon perfecting and improving that model. Instead of attempting to divert people's attention from it by showing the difficulties that might have arisen if a wholly different shaped shot, or shot of a different material, were to be used;—taking it to be vastly superior to everything that has gone before, by the experience we have got here, you ought to draw attention to the necessity of making such experiments as will perfect it.

CAPTAIN TYLER.—Will you allow me to suggest to Mr. Samuda to be kind enough to make some more experiments in punching iron plates with different sized punches, and to give us the result at our next meeting.

CAPTAIN SULLIVAN.—I think we have in a great measure gone from the original subject of the lectures. Not only do I agree thoroughly with Captain Halsted as to all the facts connected with the resistance of iron plates which he has mentioned, but I wish to add this, I think the experiment with the heavy 68lb. shot has been made as satisfactorily as those experiments upon the "Trusty. I went down to see the result of the firing at the "Alfred's" side when the plates were put there. I saw one 4½-inch plate with the marks of eleven 68lb. shot in it. The plate was as secure to protect those inside the ship as when it was fired at. I saw no crack such as Mr. Samuda thinks would occur with 68lb. shot from Whitworth's guns. While other plates of different kinds were broken to pieces the plates that had been taken off the old "Trusty" battery and put on were perfectly uninjured. I think it was ten or eleven shot that I counted; the dents were about an inch and a half in depth. At the distance from which the firing took place, I believe the force of the blow of a 68lb. shot is greater than that of a Whitworth or Armstrong shot. I think the experiment has been satisfactorily made, though only made on the side of an old 50-gun frigate, which would not be so strong as a "Trusty" built for the occasion. Therefore I cannot doubt that, with any gun we have, whether rifled or solid spherical shot, the iron plates have proved in every respect the master. I

think we might consider it perfectly set at rest whether or not ships should be plated with armour. The plating of ships with iron is such an important question and is so serious for the country that it would be a pity to close the discussion upon it in one evening. There are many facts which I believe will show that it is not so extraordinary as some think, that naval men should suppose iron ships are not the ones that are best fitted for war purposes, or even for carrying troops. I do not wish my opinion or the opinion of any one else to be taken on that point unless backed by facts. I hope to have the opportunity of bringing forward some facts to show that that opinion is not an erroneous one.

A MEMBER.—I wish to say one word. Almost all who have spoken here have pointed out the great desirableness of further experiments with shot and plates. It is the opinion of Captain Halsted that no target smaller than the "Trusty" is trustworthy. The small target which was fired at appears to have been pushed six or seven feet in the course of the firing. That fact shows, I think, that the smaller target made a greater resistance than the larger one. It occurs to me you should press upon the Government to put up small targets. If a shot makes a hole in the small targets it is clear it will make a hole through the "Trusty," therefore the experiments should be made on smaller targets than the "Trusty."

Wednesday, May 15th, 1861.

Captain M. S. NOLLOTH, R.N. in the Chair.

IRON-CASED SHIPS—*continued.*

THE "WARRIOR" AS A SHIP-OF-WAR.

IN the first lecture I had the honour to deliver before you, I stated that, so far back as 1845, the use of iron instead of wood in the construction of ships was recognised to be attended with certain important advantages; and I specified, among others, its "affording greater facility for combining a maximum of strength with a minimum of material;" as also a "greater facility for imparting that strength to every subordinate portion, and in every direction throughout the structure."

Again, in the second lecture, I quoted—as one, among other grounds set forth by the Shot Association of 1851 for their dissatisfaction with the mode of conducting the Simoom experiments—"because," as they truly state, "no means were used to test the practicability of remedying the making of splinters . . . . . by *inner* plates or other contrivances, considered by competent persons to be practicable."

Again, in the third lecture, I defined the "main question" for decision between the wooden ship-of-war, of whatever force, and the Iron-cased Ship, at present of one deck only, as standing upon the terms or conditions that — "These two structures being ships of perfectly equal qualities in every other respect, should alone differ in the fact that the one possessed the additional protection to her sides of an iron armour four inches thick, while the other possessed no such protection at all. And, with the view to distinguish between thus fixing a "principle" and working out that principle into practice, in the very next paragraph (page 58) to that in which the definition is thus rigidly stated, I so far modify its terms of requiring actual equality in all equipments, that I expressly specify certain very important conditions of equipment as "collateral" or open questions, yet to be determined by "true experiment;" and I desire here to point out that, in the above definition, as well as throughout all previous

Lectures, I have been treating of Iron-cased Ships in respect to their powers of successful contention *with ships of wood only.*

But it is obvious that there remains to be considered the equally important view of the relative qualifications for success in Iron-cased Ships, when in action against each other; for though it might be admitted that such ships must, as a rule, destroy all ships of wood they may engage with, yet, between any two plans or principles of Iron-cased Ships themselves, as adopted the one by one Naval Power, and the other by another, there may, and as I shall presently show there do, exist differences in warlike merit so great as to render the one Engine far better adapted for its work than the other; and in such case, if numerical equality exist likewise, then it is obvious that the Possessor of the superior machine must, if he so please, be able to enforce that superiority over the Possessor of the inferior one, with all attendant consequences. And thus it would seem, in the course of God's Providence, that the giant steps in human progress of the present day are bringing to decision within closer and closer limits those great struggles for paramount power which for so many ages have been swaying to and fro in the European balance; and that the great game for Naval Supremacy, the winning of which must turn the scale in that decision, is now being played out between ourselves and our powerful Rival, like the last moves on the chess-board, with choicest pieces of greatest power, and more as an effort of high intellect and practical knowledge, than, as in past times, by display of superior animal courage or mere brute force. I am fully aware, therefore, as indeed it is my express object, that in the professional remarks I am about to put before you on the "Warrior" and her sister ships, I openly submit for Public consideration, whether, according to the views propounded, and so far as the game has yet been played, there be evidence that the system under which it has been opened upon Our side is such as is best adapted to engage our ablest and most experienced players, and afford the best chance of winning in that tremendous stake which, to England at least, is at issue.

Now we know that the first armour-ships of our great Neighbour carry their plating upon wooden frames and bottoms; but there is little reason to doubt, that this is *not* intended as a continuous practice, but that it is only adopted for the moment, as a more rapid means of creating *at first* a certain force in this new Engine of war, under the security of which more time may be gained for educating that sufficient body of skilled labour to enable iron to be employed in the construction of all future ships destined to be iron-cased; the deficiency of such labour in France being a necessary condition of the deficiency of iron itself, which has always characterised that country while dependent for it on her own supplies alone. But, as she nas already commenced the construction of at least two iron hulls for her future Iron-cased ships, and as our decision has taken the same direction from the first, it may be taken for granted that in this respect the Iron Fleets of both countries will, with slight exception, be alike. But although fleets of a similar description of ships may be built of similar materials, there is ample room in iron, as in wood, for the employment of that material in ways so diverse as to produce practical results quite as much the reverse the one of the other as any arising from difference in material; and it was with an express view of enunciating in this concluding portion of my task the opinions I have ever held on this subject, that I so pointedly referred in my opening Lecture to the distinct natures of "study and practice"

in the respective branches of Naval Architecture in wood and in iron. It is in the liability to confound the special practice of these two distinct branches of one great Profession,—as if a like practice must necessarily exist where great principles are alike acknowledged,—that not only our great danger lies of committing serious error, but, as I shall show, that grave error actually has been, and is still being committed; and it seems nothing short of a violation of all analogous experience to maintain that the Art of constructing the most abstruse and complicated of all works out of wood is practically the same as that of constructing it out of iron; so that the lifetime which has been passed in acquiring eminence in the one must be held to have been equally passed in acquiring eminence in the other. I hold to the doctrine that it is the distinct speciality of the material employed which enforces a distinct and special study of its properties and best modes of application, and thereby produces that distinct and special "art" which is practically known only to those who make it their calling; and any pretension to its possession without practice should, in my opinion, never be advanced, but if advanced, it should never be admitted; for, if admitted, it would be but little less unreasonable to expect a successful issue than it would be, in common life, to expect a good "fit" were coats and boots to be ordered indiscriminately from the same party, on the ground that both were articles of clothing.

Those, therefore, who have been throughout not only the consistent advocates for Iron-cased Ships, but who, from their knowledge or study of the properties of iron, have also advocated that such iron-casing could best be carried upon iron hulls, have never for a moment contemplated, and much less would they admit, that such ships should be less complete in any degree whatever—either in their powers of offence or of protection—than if such iron-casing were to be carried upon hulls of wood. On the contrary, without demanding any superiority for iron in this respect, beyond its properties already specified, it has been felt as sufficient for the time to maintain, that gun for gun, plate for plate, from one extremity to the other, whatever any ship of wood could carry, that, the ship of iron could, and ought to, carry likewise, leaving all other superior properties of the one material over the other to develop themselves in actual practice. And it is in proof that this conviction has been entertained and exhibited throughout these Lectures, that I have opened this present one by quotations from its predecessors; but which I have also done for the further purpose of fixing the sense in which I now proceed to treat item by item on all the more important points as yet developed in the construction of the "Warrior" and her sisters, as British exponents or exemplars of Iron-cased Ships-of-War.

Proportionate Dimensions and Form.

It is now more that sixteen years since our great northern engineer, Mr. Robert Napier, announced his intention to make machinery for no private ship the proportionate dimensions of which were less than six times her breadth to her length; the experience of even that day having determined that a form for speed was not producible on lower proportions, and that any attempt to do so could only embroil the Naval Architect with the Engineer in dispute over the inevitable loss and disappointment to the Owners of a ship of inferior speed. The sharp competition for command of markets; for preference in mail contracts; together with public demands

for higher postal speed on all ocean lines, have combined to raise the proportions of length since that day to seven times that of the breadth as a rule; and seven and a half, and even eight times the breadth, is fast becoming the standard for all forms of speed throughout the Mercantile Marine. In 1845, or almost the time of Mr. Napier's decision, the late Mr. Fincham was permitted to give an ultimate proportion of five and a half times her breadth to the length of the first full-powered Screw-frigate of the Navy, the "Dauntless;" and about eleven years afterwards this example was even exceeded by the dimensions of five and three-quarter times the breadth to length given in the Admiralty's own designs for the frigates "Mersey" and "Orlando"—the nearest approach in British ships of-war, as yet upon the ocean, to those dimensions established on full experience sixteen years since, as indispensable to high speed for purposes of commerce.

The "Warrior" and her "Black" sister, however, proclaim a proximate abandonment of further official attempts to force high speed out of the inferior forms so long since condemned by the merchant; and the dimensions of 380 feet long by 58 feet beam, give to these ships a proportion of 6½ times their breadth to length, and present the only instances of high speed forms as yet permitted in the Navy. To those "professionals," therefore, who are in any degree imbued with the "progressionist" virus of the day, this tardy breaking of the official ice is very gratifying; and notwithstanding that the moving waters, as if ashamed of their weakness, have been so hastily frozen over again in the case of the "Warrior's" smaller sisters, it may yet be hoped that, under the effects of warm exultation at her own probable high performance, the example may again be not only followed but surpassed, and this ship become the happy means of breaking down that systematic "bruise-water form" which has so long been the subject of just and well-deserved reproach to the presiding Authority over the War-fleet of England; the very fastest ships of which are precisely those which bear at once the strongest testimony to high excellence in Machinery and inferior type in their Form.

In speaking thus, however, I am bound in willing justice to admit that those forms have ever been prejudicially controlled by one-sided demands for supposed facilities in "Gunnery;" demands which, at least to the extent advanced, ought never to have been acceded to, since their fulfilment has necessarily impaired the efficiency of our entire Fleet in its all-important locomotive powers, by imposing a form actually obstructive of speed, with the view to fight guns from an exceptional position, which ships of high speed would never have required to occupy with guns at all.

In the case of the "Himalaya,"—not a "home" design, but bought into the Navy and constantly employed in all climates as a troop-ship only—with proportionate dimensions of 7½ breadths to her length, with a most superior form, and with a very moderate Power—we possess the only public vessel at the command of Authority which is capable of conveying an important communication over an ocean course of 2,000 miles or upwards, at a speed approaching to that of the Postal service; and the work this ship has done, and the mode and cost with which she has done it, will, it is hoped, attract yet further attention, and produce a higher appreciation, if only of the economic merits of superior Speed-forms. But in Her Majesty's yacht, built at Pembroke from designs prepared entirely by Official talent, and in which high speed was a primary object, uncontrolled by

any one-idea'd "gunnery" demands, we see the same proportionate dimensions spontaneously adopted as in the "Himalaya," and find probably the fastest performance of any vessel yet built in England for Sea-service; thus affording clear evidence that the form and proportionate dimensions from which high speed is alone producible are perfectly known to the Naval Architects inside of the official pale, as well as out of it, if only they might be permitted to employ them for the faster classes of the Fleet.

To the Iron-cased Ships in especial, of whatever description, superior speed involving choice of distance, if not position, is as oxygen in the atmosphere, giving increased strength to all powers of Offence, and increased effect to all powers of Protection; and although not equal in form to the "Himalaya," the "Warrior's" larger proportion of steam-power will, no doubt, enable her to attain to the "Himalaya's" proof-speed of fourteen knots, whenever, and for so long, as in the case of the "Himalaya," —her bottom is clean.

General Principles of Construction.

He would be a bold man indeed, who should attempt to expatiate under this head, in a matter where those who are deepest in the deep studies of Naval Architecture, can only know that the present amount of human knowledge scarce casts a glimmer on the terrible antagonistic problems which this description of ship has so suddenly presented for solution. I therefore touch but superficially on one of its most obvious and superficial points.

The 1300 tons in dead weight of armour and padding carried by the "Warrior," on the central half of her body, represents *more than three and a half times the weight* of the entire armament of our heaviest armed three-decker, the "Victoria," taken as 121 guns, of the mean weight of 59 cwt. each; and this, no mean cargo of its description for any ship whatever, has to be carried—not low and "snug" throughout the depths of the holds, where every seaman would crave to carry it, but plastered as it were—just 220 such guns on each side—as high above the water as the level of the upper deck, and over the very outside of a frigate; that frigate then to be sent out to meet the sea in rough and smooth, and required to conduct herself as well as,—perhaps a little better than,—all other well-behaved frigates are expected to do. Now, according to our present mode of making armour and putting it on our ships;—and I, for one, believe that we must still adhere to that mode until we know of a better;—no simpler nor more effective device would seem to be practicable than that of giving to the wearer's thighs or hips, as it were, a sufficient strength and amount of projection firmly to lodge the lower edge of the coat-of-mail upon, and then from that lodgment upwards firmly to brace and bolt it to the body—all as is now done. But it is evident, that in thus arraying our "Warriors," the entire support of this enormous dead mass depends for its perfect immobility, in a lateral direction, on the rigid strength of fabric of that portion of the sides of the ship proper which carries it; such perfect immobility being, as I conceive, the essential, if not sole guarantee, against the certain destruction of the ship by her own armour. For, if by the action of rolling in bad weather, this dead mass should once acquire lateral momentum, even by that amount of "yield" which the elasticity of the side might afford, then such momentum must be expected steadily to

increase with the continuance of the cause which first produced it, until the entire brunt of its effect would have to be borne by the strength of structure of the "armour step" itself, as it is termed, which is placed five feet below water, and is the inevitable "breaking point," where separation must take place, if ever the rigid mass of armour work itself off the side; and where serious effects must begin to take place if it be permitted to acquire even a sensible tendency to do so. It is fully admitted that the powerful connection of the two sides, by both the lower and main deck beams, will operate to a great extent against the production of that motion which even the elasticity of the side might afford; but on the view thus submitted, it has long appeared to me that an additional security for that rigid immobility upon which so much depends, would have been obtained by constituting the upper deck, also, into a more rigid and powerful bond between the two sides than now it is. And to this opinion the following practical observations have led.

Throughout the winter of 1856-57, when engaged in carrying out a series of steerage experiments in the floating battery "Terror," it more than once happened that the vessel was anchored at the Nore in strong weather, rather than incur the loss of time by running so cumbrous a hulk in and out of harbour, and opportunity was thus afforded for noticing the motions of such vessels. Those motions, though deep, were all very easy, and for the four or five months "off and on" during which the experiments lasted, not a crack in the caulking, nor a weep in the side, was ever brought to notice, a circumstance which was attributed to the powerful bond between the two sides afforded by the great strength and solidity of the upper deck; qualities which had been given no doubt in special reference to shot-resistance, but which seemed to fulfil another very important condition also. The iron beams of that deck were 10 inches deep, like those of the "Warrior," but were only 16 inches instead of 44 inches apart, as are hers. In the latter case I am aware that the beams are also connected by a half-inch deck of iron beneath the three-inch deck of pine; but I believe the ten-inch oak plank of the "Terror's" deck to have been a still more solid connexion between her far more numerous beams; and as it is certain that the upper portion of the weight of armour will move with greater velocity throughout each arc of rolling, and will therefore acquire a greater centrifugal tendency than any lower portion, so the position of that tendency would seem to point out where to apply the most effective means to counteract it. And both in the deeply-studied structure of the "Great Eastern," and in the less studied but cognate case of the Floating Batteries, we see that it actually has, with all good effect, been there applied.

It may be replied, that all notice is omitted of the powerful bond against centrifugal tendency, both high and low, exercised by the two cross bulkheads, which constitute for the present, far more than any other peculiarity, the distinctive type in ship construction of the "Warrior" and all her sisters; and it is answered that all such notice is here purposely omitted, because, however ingenious may be the device of thus constructing square-ended boxes, and then turning them into fine-ended ships, it is morally certain, as I shall presently have to show, that these cross bulkheads or "box-ends" must be removed, and this "box type" again give place to the efficient and well-tried "ship type," before either the "Warrior," or any of her box-ended sisters, can fulfil their primary purposes as Ships-of-war, or be expected to maintain a fight with Iron-cased Ships of even

inferior offensive powers, but whose powers of "protection" are complete? Unless indeed "box-ends" are an invention possessing some innate merit for improving the fighting facilities of *all* Ships-of-war, in which case we shall no doubt see this notable invention of the two terminal quarter-lengths of the fighting deck securely "box-ended" off from their central halves, throughout the several batteries of the whole Fleet.

There remains, however, the substantial objection, that to increase the strength and therefore weight of the upper deck is seriously to add to the already serious amount of upper weights which, for other purposes, are inevitable; and thus we come face to face with one set of those antagonistic conditions which characterise so many of the most important problems presented by these ships; and which seem to suggest that, like obstinate fortresses, they must be "turned" if they cannot be taken, as it is proposed in the present instance to do, by adopting,—but not until practically and sufficiently prepared for,—an entire change in our present mode of armouring. That mode is to employ a single coating of massive plates, with a necessarily great thickness of solid timber to back it, and to give to the structure of the ship of iron which, as a "man-at-arms" is to bear it, the requisite strength to support, in addition to other demands, all the strains and wear and tear of this separate and monstrous suit of mail. Whereas, instead of a mode which thus inconsistently goes to weaken and imperil the very frame it intends to protect, I would have the said suit to be no separate or massive article at all, but be embodied,—probably in two or more cellular thicknesses,—into the very construction of that frame itself; and thus constitute at once both its strength and its protection during the one operation of building. In this manner also, and this manner only, as I think, "turning" with safety that other obstinate incongruity, of having to employ destructible wood, in a very destructible manner, as a yet essential condition to the protective powers of indestructible iron. Such appears to me the great Principle we should endeavour practically to work out in the future construction of such ships; and I submit it with the more confidence, as it is evident that it has not only been already entertained, but actually aimed at, in one minor feature of the construction of the "Warrior" herself. It is to be seen in those deep, strong, external angle-irons which at three-feet distances act as "longitudinal stringers" to stiffen in a vertical direction the sides of the iron ship proper, by rigidly connecting them with the 10-inch inner layer of teak padding; but very cleverly as this desirable object is thus no doubt fulfilled, it is no more than a valuable means of additional connection between those separate parts, and does not amount to that embodiment of the protecting armour into the very fabric of the ship herself which constitutes the principle I have stated. Still less is that principle in any degree fulfilled, even if aimed at, by the "tonguing and grooving" of the armour plates, which, for reasons to be presently stated, has been by myself and many others ever regarded as a mistake.

Let me, however, at once guard against being misunderstood as proposing any practical representation—at present—of the Principle I have stated as the great desideratum to be realized. We have already put forth as a first venture on our side of the "water," three separate and distinct experiments in a pair of ships each, each pair at a cost, taken one with the other, of at least half a million; or a halfpenny of Income tax a-piece; and I, for one, entertain the strongest conviction that something

very like another halfpenny-worth of Income tax will have to be spent within the next two years, before our six or seven present "specimens" can be made complete fighting-ships such as our Neighbour seems to have successfully produced as a first hit.

All the gold of California, therefore, added to that of our own gold-fields, might be mortgaged for the next fifty years to come, in attempting to work out a Principle by a further series of most costly experimental ships; while as yet the true application of that Principle has been provided for by the production of no single fact of practical experience which bears upon it. Nevertheless, whatever course we may adopt as a readier and more temporary measure for re-assuming, *if possible*, that position of International superiority in these ships which we have so obviously lost, it seems most desirable to determine upon *some* definite Principle to be embodied and exemplified in our more permanent "Fleet of the Future," that thus some distinct direction may be given to whatever talent is available, or to be availed of, for the purpose of its Construction, instead of those discursive and disconnected efforts on which all talent, both within and without the Official pale, seems at present to be amusing, rather than employing itself. Such a Principle, when once openly determined on, suggests that some sufficient means for obtaining practical knowledge of the best mode or modes in which to apply it should be the next step studied and taken. And for such preparatory knowledge to be truly practical, it seems equally requisite that it should be produced under conditions specially provided to be as nearly identical as possible with those under which the ships themselves, when built, will be put to proof by an enemy. And if a course, as thus sketched, be no other than one of common sense, then it is not a course of common sense to be still carrying out all sorts of mere fanciful experiments, to perplex us still further with all sorts of results, *no one of which will have been obtained from, and will therefore be referable to, those real conditions which will have to be met in actual fight*,—except that real guns will have been using real powder, but as often as otherwise with very exceptional shot. However, we may continue, then, for the time to carry out our present mode of armouring, it has been felt opportune to submit under this head what is conceived to be a still better Principle of doing so,—viz. to embody the armour into the very fabric of the ship herself, so as to furnish her with all requisite strength and protection during the single operation of Construction; and it will ultimately be proposed that all best modes for applying that Principle be first proved by open experiment, on a true Proof-ship—or "anvil"—of not less than 2,000 tons, to be expressly provided for the purpose, the results thus obtained alone being adopted as safe or true guides in constructing the several classes of the future Fleet itself.

I will only take occasion under this head further to notice, that in the many visits made to the "Warrior" and "Black Prince," all with myself must have felt truly proud as Englishmen at the high intelligence as well as admirable workmanship put forth by all classes engaged on such novel as well as such large works; affording ample evidence of the amplest resources, if only England's Rulers could be induced to direct a National, as distinct from an Official effort, to restore their Country out of that humiliating position into which, neither by the will nor the act of her People, has she been plunged.

Tonguing and Grooving of Armour-Plates.

Any one who may have more than cursorily inspected the effects of shot on the sides of the "Trusty," or more than merely looked at them in drawings, will have noticed that whenever the impact has fallen within a distance of six inches of the edge of a plate, it has expended itself on a "line of least resistance" in the direction of that edge as the nearest weak point; and, therefore, if a groove, say of only half an inch depth, be taken out of the edges, by so much nearer to the centre of each plate will the weakness of those edges be brought. And it will be further seen in the drawings, that there is a very serious difference of injury produced upon the plate, where from the vicinity of an edge it is broken up by the impact, and where, from being struck more centrally, it merely shows an indentation, or possibly one or more limited cracks around the point of impact. No doubt the superior thickness of the "Warrior's" plates, and the superior quality of their backing, would, under similar impacts to those on the "Trusty," reduce the effects of the "edge weakness" to even a less distance than six inches; but still the "grooving" on the one pair of edges of each plate, and the removal of metal to produce the corresponding "tongues" on the other pair, have alike contributed to diminish by so much that central position which is the least mischievously affected by the impact, and by this amount to impair the value of the plates. While the plates, therefore, are thus made less effective than they would have been if left with square edges and without that reduction of size which has been sacrificed to the "tonguing and grooving," that operation will also be seen on still further inspection of the "Trusty," or her drawings, to offer no expectation whatever that the object proposed by it will be obtained. The strength of "tongue" of the neighbour plate by no means replaces the strength of that homogeneous substance which has been grooved out of its own edge, in order to make room for the tongue itself; still less will the substance in the two lips of that "groove" replace the strength of those two cubes of metal, which were removed in order to produce the said plate's tongue; both edges, all edges, have been weakened by the operation, and rendered less able than when square to resist the effects of impact; and those effects, when an edge gives way, are so great, that whenever the impact falls within the fatal distance both plates must now be involved, more and less, in a common injury; whereas, in no instance where the shot did not actually strike was any injury whatever done in the "Trusty" to the edge of a neighbouring plate, however close to the actual impact. There is thus every practical reason to conclude that the reverse of what was proposed by the "tonguing and grooving" will in reality be obtained, viz. common injury instead of mutual support; two, it might even be four, plates, becoming liable to be made "hospital cases" by the same shot, where otherwise there might have been but one.

Neither does any advantage appear to have been derived from this operation towards embodying the weight of the armour into the strength of the ship herself;—if such, indeed, was any part of its aim. Square edges are, at least, as capable as "tongued and grooved" ones of being fitted to that hundredth of an inch of closeness, which is so admirably shown in the

"Warrior's" coating. If left square, the plates would have closed with a somewhat weightier force, whilst the bolting in both cases would be the same; and whatever stiffening of the side the mass of armour might produce, on the score of the contiguity of its plates, by thus resisting any tendency to motion exceeding the hundredth of an inch, such "stiffening" would be in both cases alike, with exception of a little more friction of parts in the "tongue and groove" system.

On the other hand, what has been the actual and contingent expense of this refined operation? What increased time in fitting the "Warrior's" armour has this mode of doing so cost? What modifications in the form of her sides which might have been otherwise desirable, have been sacrificed to conditions imposed by this mode of plating them? And last, not least, what increased time, labour, and direct expense must be lost in refitting this armour whenever injured?—how much of that which is entirely uninjured must yet be entirely removed before that which is injured can be gotten at for removal at all? All these items, except that of lost time, admit of a money calculation; and "lost time" may have a cost beyond all money calculation; but if all, when ascertained for the "Warrior" herself, be multiplied by their due proportion of "seven," for the rest of the family, we should see a sum for the bare use of which many would gladly compound to give "gratis" the remnant of their earthly services. They have however been adduced thus pointedly, because they so aptly illustrate what I have meant by a *bonâ fide* experimental or proof-ship being always in readiness to put to practical test all such and other proposed improvements as this "tongue and groove" system very rationally presented; but with respect to the real merits of which no more was known when it was adopted, except its greater cost in all respects than the square system, than is known about it at this moment. Whereas if two 20-feet surfaces of equal plates, with and without the "tongue and groove" had been formed over some section, duly prepared like the "Warrior," of such 2000-ton "anvil," as proposed, and had then been subjected side by side to an equal hammering from "smooth-bored" and "rifled" artillery, with all practical missiles; the time of "fitting" and "removal" being recorded likewise in both cases, then the true merits of the proposal would undoubtedly have become known, and the sum of money, past, present, and future, which might thus have been saved in the case of this one instance alone, would go far towards the construction of what virtually is none other than an appropriate apparatus of "Weights and Measures" by which to test for adoption or rejection the true merits, as far as detectable, of those numerous inventions which the present transition circumstances must inevitably, and in many cases advantageously, call forth from the aroused talent of the Country.

Height of Port-sills.

When the late Mr. Fincham designed our first full-powered Screw-frigate, in 1845, he selected the same height of 6 ft. 6 in. for her midship maindeck port-sills, when at load draft, as was then carried by our best 26-gun frigates; and this height the ship always maintained when every item of equipment was complete, except, that if leaving Harbour under

steam, the boiler-water always reduced it by about four inches, which the first 24 hours' consumption of fuel again restored. Nevertheless, the prime defect of the design is the lowness of the main-deck port-sills, and for days together, when cruising off Cape Finisterre, not one of these ports could be opened when a 26-gun frigate could have fought her main-deck battery with complete convenience, if not with a dry deck; the circumstances which admitted of this comparative experience occurring so frequently during the ship's probationary trials; and always with the same conclusion; that it enabled a practical judgment to be formed that the main-deck port-sills should have been at least two feet higher, or 8 ft. 6 in. out of water, in order to have enabled the battery to be fought with the same convenience in the same state of weather as could be done with the 6 ft. 6 in. port-sills in the 26-gun frigate. Neither could this defect be attributed in any degree to the motions of the ship, for nothing could afford a more striking contrast in this respect to the superior ease, and even grace of motion of a ship with five and a half times her breadth to her length, when compared with the deeper and more abrupt motions, both in pitching and rolling, of ships with only the ordinary three and a half times their breadth to their length. But the fact, unwelcome, unexpected, and undeniable as it was, cost many a discussion among those on board, and many an anxious hour of study to her Designer, who felt, under the circumstances, that the cause could only be sought for in some hitherto unrecognised principle in the design, and who was greatly relieved on perceiving at length that it lay in circumstances practically developed for the first time by an entirely new description of ship, and which went to establish that "height of port-sills" was no matter for mere fanciful selection from what might be effective in other known classes, without reference to similarity in other important conditions; but that it had direct relation to the very important condition of gross displacement; or, in other words, that the fact of the "Dauntless" being unable to fight her main-deck battery in a state of weather when a 26-gun frigate, with the same height of port-sills could, was, paradoxically enough, due to the further fact that the "Dauntless" was a ship of nearly double the size of the other.

The gross displacement of the one ship was 2,440 tons, that of the other may be taken as a maximum at 1,300 tons only. A weight of 16½ tons is required to depress the larger ship in the water one inch, and 10 tons are sufficient to produce the same effect in the smaller. Now, in "flotation," as well as "depression," the same relative proportions would hold good, and the larger ship must require a body of 16½ tons of water to raise her one inch above any common fixed point of level, where the smaller one would require but 10 tons; and the practical effects of this difference were exhibited when in any given state of sea the amount of surface oscillation which lifted the smaller ship an inch, did not suffice *equally* to lift the larger, and gave her to the extent of that insufficiency the character of a half-tide rock as compared with the other, *i. e.* the sea broke most where there was most resistance, or, where the yield to its motions was the least. As in all cases, the progressive motion of the ships themselves would go far to aggravate the rise of water on their sides; but here again the same relative proportions would produce the same relative difference

of effect; as would be the case likewise where the amount of surface oscillation, instead of having an equal distribution over all portions of the ships at once—as it never has—should, as it always does, affect one portion far more than any other, the water thus breaking in sometimes through some ports, and sometimes through others.

And now to apply these facts and deductions to the subject before us. So soon as reliable statements established that the ports of the "Gloire" were but little higher than those of the "Dauntless," say 7 feet, it became evident to all who were aware of the experience here stated, that taking the "Gloire" to have double the displacement of the smaller ship, her main-deck ports must practically prove to be lower, and her main-deck battery even still more liable than that of the "Dauntless" to be swamped in rough weather; quite irrespective of "motion," and equally so of whether she was plated with iron or with cork; if only in both cases the gross displacement were the same; and it was thus evident that her eminent Designer was not aware of the experience on this peculiar, but very important point, furnished by a British frigate. But has that experience been taken advantage of in our own similar constructions? Has the 9-feet height of the "Warrior's" ports been determined "empirically," like the 6ft. 6in. of the "Dauntless," merely because 9 feet is found sufficient in other frigates whose dissimilar conditions of displacement, as between the 2,440 tons and the 1,300 tons, have again been entirely overlooked? It is much to be feared it has been so; and, if this be the case, then we must expect to see in these designs of 1859 a repetition of the same error as was found in that of 1845. The error was then evidently caused by a previously unrecognised principle, for in no previous description of single-decked ships had it ever occurred to connect a height of ports of 6ft. 6in. with a load displacement of 2,440 tons, and nothing was therefore known of the practical defect which such selection involved; nor has there been any liability to repeat the error until now. The "Dauntless" herself has never been repeated; she fully established the perfect practicability she was designed to prove, that, namely, of embodying into one and the same ship the conjoint powers of the complete Sailing-frigate with those of the complete first-class Steamer; and having thus become in principle the mother of all our present full-powered Screw-frigates, her own part has been fulfilled, and the height of main-deck ports in her progeny of double her size has been selected very properly, not from that of the smallest, or 26-gun, but from the largest, or 50-gun sailing frigate. But circumstances of the present day have again arisen for determining a height of main-deck port for a frigate with a gross displacement of 9,000 tons, and requiring 45 tons intead of 16½ tons to "depress" or to "float" her one inch; and who shall say that a height of 9 feet—the height of a moderate frigate's ports—is a better proportion for these 9,000 tons than was Mr. Fincham's selection of the 26-gun frigate's 6 ft. 6 in. for his displacement of 2,440 tons? If, therefore, we were right in our judgment—and as yet there is nothing but judgment to guide us—that 8 ft. 6 in. was a minimum height to have enabled the "Dauntless" in rough weather to have used her main-deck battery against a 26-gun frigate, then the 6 inches more height of the "Warrior," with a displacement more than

three and a half times that of the "Dauntless," betrays, I fear, the existence of the same defect, to be attended with the same serious consequence; and though it is possible that this defect in her case is not so great as it is in the "Gloire," with a displacement double that of the "Dauntless," and a height of ports but 6 inches more, yet the advantage, if it practically exist at all, of carrying open ports longer in bad weather on board the British ship, can certainly not be quoted as in the proportion of 9 to 7.

But quite irrespective of particular ships, we have here another of those problems, attended with such terrible and antagonistic conditions, that they seem alone soluble by some entire change in our present principles of ship armament, corresponding to the entire change in the character of the ships themselves. If "height of port-sills" must increase upon some given, though at present unknown, ratio, with increased displacement, in order to ensure the same use of the batteries in the same weather as in our present frigates, then must the area to be armoured also be proportionately increased, and, worse still, the centre of gravity of the whole mass must, in a yet higher proportion, be raised with it—evils which can alone be met, according to present knowledge, by resort to increased displacement over again—the remedy thus aggravating the disease. And our only alternative seems to lie in some successful attack on these two anomalies in our present mode of ship armament. We place our guns in those extremities of the ship's oscillation where they most conduce to aggravate that oscillation, and are most obnoxious to all the "disobliging" effects of the ship and of the sea in their mutual struggle against each other, which such oscillation produces; and, in order to enable the guns to occupy this position—the sole merit of which is, that it "seems" the least mischievous of any other when in action, to the ship herself,—we require to embark double the number we require to use. Thus the difficulties connected with this new description of ship, as at present armoured, seem to point for solution to some complete change, which, by *centralising* the guns, shall make one set only as available as both sets now are for the use of both sides; dispensing with the other set altogether; removing the remainder from the most unstable to the most stable position for platform, out of the scene of conflict between the ship and the sea altogether; and reducing to a minimum, if not entirely removing, all difficulties arising from that ugly connexion between "gross displacement" and "height of port-sills," which for a second time has evidently been violated.

Steerage.

If it were required to construct a mechanism of great power for the sole purpose of producing a large and solid cylinder of water, having the greatest attainable velocity, and which should divide itself on the two equal sides of a ship's rudder, thus fixing it in a central position by what we will term a "water-wedge;" then for such purpose no human invention yet known could be more perfectly adapted than are the engines and screw of a Screw-ship; and in truth, this very effect the engines and screw of every Screw-ship do directly and primarily produce; the speed of the ship, when free, being none other than the indirect and reactionary effect of the force employed by the engine when giving to this cylinder of water its great velocity.

Again, the "steerage-power" of such ships is none other than the indirect and reactionary effect produced on the ship when free, in a lateral, instead of longitudinal direction, by means of whatever mechanism may be employed, within the ship herself, for the purpose of forcing the rudder out of its "water-wedged" central position, and compelling it to present, at any required angle, the one or the other of its sides to the velocity of that cylinder of water the engine and screw have produced for the sole purpose—if we choose so to view it—of thus giving to the Screw-ship an amount of "steerage-power" hitherto attainable in ships of no other description.

This "steerage-power" commences with the first stroke of the engine, and increases in direct proportion as the engine works up to its fullest effort; and if a rudder—say what is termed a "balanced rudder"—having a surface, when at its most effective angle, equal to the entire diameter of the cylinder of water, were to be forced by a sufficiently powerful mechanism across the stream of that cylinder when at its highest velocity, then the entire available power of the engines and screw would be employed in turning the ship, according to pleasure, in a lateral direction, while they would be no less employed in giving her full-speed through the water; and, from this maximum condition downwards, every amount of "steerage-power" it is desired to employ is entirely at our disposal in direct proportion to the amount of surface given to the rudder, and to the efficiency of the mechanism whereby we attempt to work it.

There is this further practical peculiarity. The "steerage-power" thus derivable from that cylinder of water is entirely irrespective of that which might be, and when not using the screw is, derived from the mere headway of the ship. The cylinder itself is the produce of the engines and not of the headway of the ship, the velocity of which it always far exceeds, analogously, and in some unknown relation, to those same laws whereby the shot is projected one way, while the gun recoils in another; and thus the mechanism for working a rudder in all such ships must be determined, not by any calculated speed of the ship, but entirely in relation to the power of the engines producing the stream of water which the rudder works in, and whence it derives its effect.

Such, in their simplest form, are the mechanical facts out of which have grown what is termed the "difficulty of steerage" in Screw-ships; and the term no doubt is literally true, as it relates to the tremendous effort required to lift our "routine system" out of the depths of that "rut," rather than "groove," which has been worn by 150 years' use of those perfect proportions of "wheels and axles," and "pulleys" and "levers," which furnished the mechanism for working rudders throughout the long period when the force of water producible by any headway which the power of sails or of paddle steam could give, constituted the only source of our available "steerage power." But there is no circumstance connected with modern Progress which points, in my opinion, with keener reflection, if not reproach, on the inaction,—for it is not incapacity,—of every concerned Department, than the fact that at this moment our Screw-Fleet is entirely unprovided with any mechanism whatever, competent to ensure the safe steerage of our faster Screw-ships when at full speed; nothing more to this end having as yet been done—notwithstanding repeated representations enforced by actual accidents—than reluctantly to inflict some slight modifications

on the ancient apparatus, just sufficient to prove that its inefficiency is fully known; but that the self-complacency of "Officialism" cannot be expected to make such an effort as shall provide a truly efficient one in its stead. Yet the Screw-ship has been our adopted model in all classes for the last 12 years, and her peculiar powers of steerage were known, and used, and analysed and recorded more than 20 years ago, in the first performances of the original "Archimedes." The word "difficulty," then, in this matter, conveys in its true application a reproach, the sooner removed the better; but if with the view to cover that reproach it be attempted to fix it as implying some disability in the Screw-ship herself, then is it little less than an inconsiderate libel on one of the most beautiful provisions, among several others, in the essential economy of Screw Propulsion. Since the general adoption of that Principle into our Navy, professional, and I must say superficial, objection has constantly been taken against giving a sufficient speed-length to our Screw-ships, on the score of increased difficulty in steering them; whereas I have shown that a "command of helm" is called forth by the very first stroke of the engine, and actually precedes the production of that headway which involves the risk of accident; so that, assuming "length of ship" to mean large power for the purpose of high speed, then are we at full liberty to adopt in our Screw-ships whatever length the demands of either War or Commerce may impose, in perfect assurance that, whatever risks the highest speed may seem to entail, there is a governing power in the corresponding velocity of that ever-following cylinder of water more than sufficient for safe guidance out of every danger, if only the Providential gift be used as fully and freely as it has been bestowed.

The following facts will illustrate the foregoing remarks. By a long series of exact and practical experiment, extended over the winter of 1856-57, it was established that every angle of the rudder up to 40 degrees from the line of keel produced a sensible effect in the shorter time, as well as smaller space, within which a screw-ship 200 feet in length of keel could make a circuit of the compass. So that, testing the value of these degrees at series of 5 degrees at a time, it was found that a Screw-ship which could command, when under steam, an angle of rudder up to 40 degrees might avoid the casualty of collision, or taking the ground, which she could not avoid by the command of an angle of 35 degrees only. In this case, as may be supposed, the power of the engine (200 horse-power nominal) was sufficiently low to admit of the ordinary steering apparatus being employed to obtain the above maximum angle; and long and varied experience requires the admission that in many cases a modification of the ordinary apparatus will, *with great effort*, allow the full angle of the rudder to be obtained when at full-speed with engines of even 400 horse-power, provided they be engines of those older types where the nominal and real horse-power do not differ so largely as they now do, and are increasingly doing. But with the more recent 400's, and from that amount up to 600 horse-power, the ordinary and spare sets of apparatus both together will scarcely suffice, with fullest effort, to obtain an angle of 20 degrees; while, from 600 horse-power and upwards, all available means will probably fail to secure, even as a temporary effort, 15 degrees at full speed. What amount of angle has been actually procured in the case of the "Howe's" 1,000 horse-power was probably not measured; but the rudder was so

nearly a "fix" as to mar the attempt to ascertain her maximum speed; and it has not yet appeared that the deficiency of command over it has been rectified by any of the plans proposed, so as to enable her proof-trial as yet to be made. Of course, whatever amount of "rudder-angle" the present apparatus can command, to that extent it is effective for steerage purposes; but the difference between that amount and the 40 degrees, or whatever less angle the rudder itself may be actually "bearded" for, is the true measure of its deficiency for its purposes, and therefore a true measure of the increased risk and actual deficiency in the power of manœuvre which its persistent use entails on the whole Fleet, affecting most the most valuable ships in it. For whenever manœuvres under steam shall come to be required from a large Fleet in presence of an enemy, and gun after gun goes to enforce the rapidity as well as precision of any "change of formation," the small command over the rudders of (say) 30 sail-of-the-line, thus intent on pushing on at full speed "into station," may give rise to awkward casualties before a single enemy's shot is fired; since, like all other collisions, there must be two parties to each.

But of all ships requiring the utmost steerage command, the "Warrior" and her sisters, for more than one reason, stand foremost, and the following data of one of the proof-trials at Sheerness will enable us to estimate beforehand with tolerable accuracy the extent, as at present provided for, to which she will be able to use the "steerage-power" produced by engines putting forth the highest effort ever yet employed in driving a 24-feet cylinder of water, at the greatest attainable velocity, against a ship's rudder. In the autumn of 1859, at the proof-trial of the "Hood," 91 guns, and 600 horse-power, every preparation having been made to command the largest available angle of rudder so as to diminish as much as possible every risk of accident when at full speed, it was found that, with a mechanical effort equivalent to 256 men working a lever of 5 feet 9 inches, no more than 14 degrees of the rudder could be commanded, the engines working up to a real power of 2,300 horse-power. Now, if the rudder of the "Warrior" be constructed on any established proportions, its surface will be greater than that of the "Hood," and it will have a deeper immersion; the cylinder of water to wedge it with will also be larger, and the velocity of that cylinder be the produce of at least 5,000 steam horses; and truly nothing can surpass the simplicity, if not the efficiency, with which it has been provided that this "Niagara" of "steerage-power" shall be employed for the "Warrior's" use in battle. It has evidently proceeded on the principle that if one ordinary wheel won't do, two will; if two won't, then three will; if three won't, then four will, and so on, the series ending for the present at the latter number. There are the same cherished proportions as of yore between all those dear old wheels and their barrels. There are the same three dear old turns each way of the tiller ropes, patiently expecting the accustomed order "Hard a-port," or "Hard a-starboard," which is to use them up alternately, as for long ages past these orders have done. There is the same dear old single-sheaved pulley, with the "standing part" of the rope "brought back," to give increase of power, as was always the wont where short tillers only could be used. Not a modification has been permitted to mar the antiquity of all these details, which grew up under a state of things so entirely different from those to which it is still persisted

to apply them, the only approach to modification being, that, whereas in these days the single-armed "tiller" has been replaced by the double-armed "yoke," each arm of each yoke has been separately provided with an entire suit of the ancient apparatus in all its purity; so that, as before said, there are two wheels to do the former duty of one, and the whole quadruplicate system is thus separated off into two distinct duplicate sets:—The one on the one deck, the other on the other; the one to the one yoke, the other to t'other; each wheel of each set, and each set with the other set, being no doubt supposed, and even intended, to work together; but as the realisation of such common intention must depend on a common action, on whatever may be the common sign or order given, it seems likely that a very clever fugleman will be required in order to provide against the one wheel working *against*, instead of *with*, the other; and the probability of this "fix" will be multiplied rather more than four-fold when the whole system—the one set of wheels on the one deck, and the other set of wheels on the other deck—comes to try and work in combination; as I now proceed to show that it must do, and very hard too, if ever it be intended that the "Warrior's" rudder, when racing at 14 knots, shall be commanded to anything like the limited extent of that of the "Hood."

Four men is the appointed complement at each wheel, the proportions of which to its barrel give a power of $4\frac{1}{2}$ to 1, producing an effect equal to 18 men on a pulley purchase of 3 to 1; or 54 men on a lever of 7 ft. 6 in.; thus showing a representative number of 810 for each duplicate set of wheels; or, with both sets of wheels working both yokes on both decks, giving a number of 1620, which rather exceeds the similarly obtained number of 1472, representing in like process the entire mechanical effort by which the 14° of the "Hood's" rudder was procured. But, as before observed, the "Warrior's" rudder is larger than the "Hood's;" it will be more deeply immersed; and will be "water-wedged" by the effort of 5000 steam horses instead of only 2300; so that others may now form a judgment as well as myself, of how far the "Warrior's" rudder is or is not likely to be in the same "fix" as that of the "Howe;" and it would have been infinitely more gratifying to have been able to notice under this head how the universal experience of past years had been duly taken advantage of in this important instance, instead of thus pointing to its having been so evidently and openly disregarded; for the comparative data of the "Hood," I have thus quoted, among many such, instead of being unknown at Head Quarters, has actually been made the occasion for a special act of legislation throughout the Navy.

Any one who has seen the turning of a gunboat under steam, will know that it is so rapid as to produce almost a sensation of giddiness at the motion; and the simplest calculations would have sufficed to have shown the proportions of surface and angle of rudder and the "helm-power" with which such effects are produced; any proportion of which might then have been provided for in the "Warrior" and her sisters on sure grounds; and no ships ever yet built will more require it in their day of trial; for, as they at present are, the bare possibility of their being able to fight an action *at all*, will depend, more than on any other single quality, on their "Power of steerage."

Fouling of the Bottom.

If the speed of the "Warrior" should be reduced from 14 to 12 knots,

which a reference to the cases of the "Himalaya" and other Transports of iron will show to be no excessive loss from the rapid and great fouling of the bottoms, then such reduction will, in accordance with well-known laws, be equivalent to a loss of about one-third, or 400 horse-power nominal in the efficiency of her engines; and for this loss there will be no compensation in any corresponding reduction of the fuel used; for the whole steam stable will have to do its utmost to obtain even this lower speed and will demand its food accordingly. Therefore, as compared with efficient work, this lower speed must be obtained at a loss of about £40 a day. Present experience tells us that this loss must be incurred, throughout such period as the obstruction may be allowed to last,—twice a year; and according to present knowledge, the sole remedy against both its duration and increase, is in a process of docking, cleaning, drying, painting, varnishing, &c.; and who is to say how long our 6000 ton ships, with a draft of 28 feet, will not have to "stand knocking" at dock gates, which they cannot enter until tides permit this remedy to be applied; while they must be equally forbid to go to work at sea again until it is applied, under pain of the horses eating their very heads off without avail. Then again, our great National arsenals, of which we speak so proudly, possess at present but three docks between them into which such ships can be taken at all; and one of these, according to report, is to be given over to a process of experimental gestation for the next two years while producing a "Warrior" of its own; so that the foresight of Liverpool in constructing its wondrous system of new "graving Docks" seems likely to prove a piece of great national good luck, if, indeed, the Mersey itself can, without risk and delay, accommodate the frequent ingress and egress of ships with such a draft of water. The number by which we may prepare to multiply this annual loss in money, time, efficiency, and labour, but, above all, in absence from "station" when possibly most wanted, amounts to seven, to be multiplied again in each case by two; so that there is likely to to be a very pretty little Public bill to pay each year for the continued liability of iron bottoms to foul, even if our Iron-cased ships should be limited to the number at present built or building; but, as I gather that my countrymen intend not to give over to our great Rival "permanently," that numerical superiority she has contrived so astutely to seize from us "at present," the above multiplier is likely before long to be largely augmented, and thus the matter, in whatever light viewed, assumes the proportions of a National question; and it is alone by regarding it in this important view that it is at all likely, in my opinion, to be successfully solved; for, in respect to Commercial shipping, it has been felt as a weighty question long enough to have been solved many times over before now, if its solution had not been in reality a very stiff job.

No doubt I hear a chuckle—and a note or two of it has come from very high up in the tree—over this "fix," which the present rage for iron has seemed to bring us into, and which is doubtless regarded by "the adversary" as a just judgment for our desertion of "wood." But there is another, and I think a far wiser, as well as more truthful, way in which to view the matter, serious as it has now become; namely, as a judgment for the *past*, rather than for the present; for it is but one of the many other regrettable results of the refusal of former days to see in the proposed gradual substitution of iron for wood, a feature of that law of Progress to be recognised throughout the past twenty years, and to which, willingly or unwillingly,

we all now find ourselves compelled to bow. But the stream, which would then have risen with steady flow so as to have been kept under perfect control, was dammed back for purposes we will not again advert to; and this is but one of those points where the banks are now bursting, as they will yet do, I fear, at many others, so that any reasonable money-price by which we can clear ourselves of this threatening "difficulty," before others arise to perplex and confuse us still further, may prove to be the lightest payment we shall be permitted to make for our error.

I know that there exists somewhere, a Committee of some sort, said, among the other numberless desiderata of the present position, to be engaged on the discovery of some means to keep clean the bottoms of iron ships; but if this discovery had been one to be picked up, "among many others," simply for the first effort at picking, its very nature and consequences proclaim that it would not have remained to this day as a discovery for any Committee to look for; and the best and truest men out of the good and true of any such Committee are precisely those who would best know that large and difficult objects are accomplished only by correspondingly large and competent means specially adapted and devoted to them. In my own utter ignorance also I venture further to ask, has ever any one yet known any large measure of practical good to have been brought forth at all by any one of these *quasi* Committees which, under the "secret and exclusive" system, grow up in a night, and are cut down in a night, and are to be found incubating about in the secluded chambers of so many official precincts? Even the great egg of the great Defence Commission, so soon as it was brought to the light to be turned over and examined, has been justly pronounced to be quite addled. And if the Armstrong egg be ever hatched into a real live brood of chickens, they are likely to possess no feature, beyond noise and gunpowder, in common with the first specimen so triumphantly selected to be parent to the race. The question then here mooted is one of National interest far above the money cost involved in its solution, and, if only in the bare hope of drawing National attention to it, so as to elicit an expression of Public Opinion, whether a more public mode of solving it may not this time be adopted, I beg to set the ball a-going thus:—

1. May the Legislature be induced to vote at once a sum of, say £10,000, for the discovery of the most effective means of keeping clean the bottoms of ships of iron to the same extent as copper now keeps clean the bottoms of ships of wood; competent judges being publicly appointed, the scale and conditions of awards being published, and the whole available talent of the Country invited to compete.
2. Let every facility of all Public establishments, and all Official and relevant information, be fully accorded to all competitors whom the judges may acknowledge to be such; all necessary precautions being taken to distinguish between true men and mere pretenders.
3. No competitor securing an award to be allowed to patent the discovery awarded.

Should a twelvemonth of such effort fail to elicit what is required, even the test afforded by such an effort would be most valuable in its proof that, to invest iron itself with the desired property, must be left for more time, or for some happy accident to determine; but, in order that the effort be not barren, let the terms of competition equally apply to the substituting

for iron of any other metal, simple or compound, but equally as strong and otherwise unobjectionable, and the reasons for suggesting such substitution are these. On the first introduction of the Screw, the naked and projecting ends of the iron shafts, when the Screw was raised, were found liable to very serious corrosion from the action of the ship's copper, but far less so when sheathing of "yellow metal" was used instead of copper. There was also a great obstruction to speed caused by the large flat surface of the fore part of the after stern-post or rudder-post, against which the water from the screw struck with full force. Satisfactory experiments, therefore, having first been made as to strength, it was determined in 1847 in the case of the "Amphion" to give an after stern-post and rudder of a particular mixture of "yellow metal;" and an offer was made by Mr. Muntz, should the plan be sufficiently adopted in the Navy to justify the expense, to erect rolling machinery of sufficient power to roll out rudders and stern-posts in a single mass each. The plans were all completed in detail, and although, by substituting the means now employed for the same ends, those plans were never executed, yet no doubt was ever entertained that a strength equal to that of iron would have been obtained for the parts thus made in "metal;" and it was seen then, as it would be seen now, that if the first cost of such substitution was very high, yet the material itself was one which would always realise back again, if required, all but a small proportion of its cost.

Armament.

The main battery of the "Warrior" is to be armed throughout with the largest gun, invented for *exceptional* use, ever yet proved in action in the Navy,—the 95 cwt. solid shot 68-pounder,—in respect to the merits of which gun, as an armament for an entire battery, I beg leave to expose my entire ignorance by putting the following question. Although quite aware that it never has been put to proof as an arm for a complete battery in any naval action, I ask, has it ever undergone any representative proof, or rehearsal of its use in such an action, and if so, when, how, and through what length of time did the rehearsal last? And the question is put for this reason. About four years since, when extolling the beautiful precision and power of a sea-face battery of 56-pounders at Gibraltar, it was stated on most competent authority that, powerful and precise as the guns truly were, it yet surpassed the physical power of my informant's artillerymen to fight them with any rapidity for a continuance of more than three-quarters of an hour. Now, in respect to all Naval engagements, there is a law which stands unchanged amidst other changes since its first practical establishment—that all other circumstances being alike, the ship which can deliver at her opponent in any given time the heaviest weight of equally destructive metal, must ultimately prove the victor in the game, if she can maintain her superiority. And it is evident these conditions have at least as much regard to the physical powers and endurance of the men as they have to the power of the gun. Therefore, if such a rehearsal as I have pointed to has, as I believe, never yet been made, any more than that a real action has ever yet been fought with 68-pounders only, then I would presume to suggest that, before proceeding further in the same direction, the real

practicability of the "Warrior's" intended armament be put to representative proof in some such way as this.

Take some sound specimen from among the Floating Batteries, all the ports of which ships are fitted for these guns, and place therein side by side the 95-cwt. 68-pounder; the 10-inch 84-cwt. Paixhans; the 8-inch gun of 65 cwt.; and the new 58-cwt. 32-pounder. Appoint picked crews for each, and with them send the vessel to sea for a series of practical rehearsals. Let each gun be fully manned; each shot be fired under superior direction, as when in actual action; and the number delivered in each case carefully recorded over a period at each rehearsal of three hours; —but a limited representation of the probable time of fight between two completely-clad armour ships,—ten minutes of rest being allowed at the end of each hour to denote the time the guns might be out of action during "manœuvres." Let a separate rehearsal be made for action with one broadside only; for action with both broadsides throughout (for Iron-cased Ships must be prepared to take station in line of battle); and for action where one broadside and both broadsides are used for equal times; the whole to be repeated with the ship in motion in a moderate sea as well as in smooth water.

We should thus obtain an amount of true knowledge far greater than, I believe, we at present possess of the real conditions which in real action the plan of adopting exceptional guns for complete batteries will inevitably expose us to, and we shall know how far that exposure will or will not exceed the physical powers and endurance of our men; for I do not at present believe that any mere "gunnery exercise" which may have been undergone in such of our frigates as are armed throughout their main battery with 10-inch Paixhans, has ever had regard to eliciting the truth of this physical question, nor ever been of sufficient continuance or severity to do so. It will be quite apparent that I am here speaking in entire ignorance; and therefore it is that, whatever might be the results of such a series of rehearsals as is here proposed, such results should *in extenso* be made publicly known. There is a sort of International Copyright custom, if not treaty, in these matters, under which it is openly provided that all such knowledge shall be at once imparted to where it may most effectively be used against us; and there is no more mischievous and unreasonable feature in the present jealous system of "secret and exclusive" experiment than that which thus lays bare every result to the study of alien Governments and their servants, while at the same time it compels British officers who may have the responsibility of applying those results, to obtain any competent knowledge of them beforehand, by means over which he rejoices as much as when a rogue has outwitted a Chubb's lock; and the unwilling ignorance which I may have been here exposing is thus a true measure of the reprobation which attaches for it—not to me, but to my betters.

Such a rehearsal, however, even if not required in reference to the present, will afford, I believe, true value in reference to the future. Within twelve months we have jumped from 80-pounders to pounders of 100, 120, 200, 300—all Government projects, under the direction of our great Rifle Engineer, and all projected for the purpose of cracking the sides of those abominable Iron-cased Ships, if they are such fools as to come near enough to the forts which mount them—but the smaller of which may be chari-

tably disposed of to enable said Iron-cased Ships to crack one another's sides at sea; and it therefore seems desirable, before these projects grow once more into very expensive and perhaps useless facts, to ascertain whether it be physically possible for us to use these guns when made; unless, indeed, it be contemplated to supersede manual labour by mechanical art—a change which in truth seems proximate enough, but which will, I believe, when once entered on, present all the awkward conditions of a little concentric revolution of its own, and its introduction therefore had perhaps best be deferred until some of the many larger circumscribing "revolutions" our hands are now so full of, have been first satisfactorily disposed of.

Size of Ports.

In 1855 plans were submitted for reducing the usual sized and shaped ports of the Floating Batteries then building to a circular form with only a 2-inch clearance around the muzzle of the gun; the chance entrance of missiles from without being thus reduced to a minimum, while allowing the free use from within of rifles and revolvers against boats or boarders. By an adaptation of the ordinary gun-slide, the working pivot was brought immediately below the actual muzzle of the gun when in its fighting position, which was kept entirely "within board," all training being given by embrasuring the ports internally—precisely, in short, as has recently been done throughout in reducing the size of ports of the "Warrior," except as to the form and extent of reduction. The rejection of the proposal, which was presented in model, was based on the fact that the embrasuring of the ports had reduced them externally to a feather edge at the junction of the timber with the armour, and it was urged that a shot at that point might burst in the thin portion to the destruction of the gun's crew; to which it was replied, that at least until this particular shot came, which might not come at all, it would be well to have protection against all others, which would be better than no protection at all, besides the probability that when it did come it might do quite as much mischief by entering freely as by first bursting in the feather edge; and the fact of the proposal itself, and the reasoning in support of it, would thus seem to convey approval of the recent and similar change which has been made in the ports of the "Warrior."

But, in truth, the cases and uses of the two descriptions of ship are very dissimilar. The Battery, if employed as originally designed, would be laid as close as possible to the walls of those amphibious fortresses, such ships were specially intended to destroy; and if some few guns might have engaged the nearest guns of the fort, the great body of them would be employed to knock into one long breach the masonry space between the two nearest casemates, and then, directing their power against the space between the next two, have brought down at least the opposed portion of the masonry, as the individual share of each Battery engaged in the joint destruction of the entire fortress. Now, for such an operation as this, no range of vision through the ports was requisite, the guns and the object being both fixed close in front of each other; and whatever alteration might be required in the direction of using the battering force would

be obtained by means of the helm, or by working the fore-and-aft moorings, not by the training of individual guns. It was, in short, a *duel à l'outrance*, which was specially to be provided for in these ships; for, when once fairly in position and engaged, there could be no cessation or retreat until the one party or the other were destroyed; and, as the piercing of 20 feet of solid granite must be a work of time, every possible means of protection was due to those engaged in the job.

To this special and limited purport of the Batteries of 1855, the usual and more general purposes of the "Warrior" as a ship-of-war bear no analogy; and the requisite preparation for such general purposes in respect to the character and use of the ports, is in no degree affected, and need in no degree be changed, merely because the ordinary outer planking of a frigate's sides happens in the case of these constructions to have a further and extraordinary "outer planking" of iron. The amount of "range of vision," as a necessary concomitant with the amount of "training of guns," which the experience of all naval Nations has determined to be given to the ports of ships as essential to the effective use of their guns, is not, and cannot be affected in the least degree by the perfectly irrelevant fact of this iron peculiarity. If the "range of vision" obtained by size of port in any unarmoured frigate be requisite for the effective use of her guns in action, then such requisite must remain unchanged if an iron coating, whether thick or thin, be applied to her sides. But if, on the other hand, it be a new discovery, found out while yet in dock, that it is of advantage in the use of her guns, for the "range of vision" given by the "Warrior's" former sized ports to be reduced, then it must either be shown that this requisite has been produced by the application of iron plates to her sides, or else this advantage is applicable, and should at once be extended to the ports of all our other Ships-of-war. And it would be but a specious reply to say "that the range of view in the alteration of the 'Warrior's' ports has not been reduced, since the two men stationed nearest the port have the same range of view as before;" because this retention of the same facilities of sight as before, by parties who have nothing to do with firing the shot, is no compensation for that privation which has thus been inflicted on him who alone does, and is responsible for firing it, and whose position when firing is as far removed as it can be from theirs. Between any two ships in motion—possibly in opposite directions—accuracy of fire is an act of instinctive judgment on the part of the firer, dependent on his careful watching of the extent and direction of compound motions; and not only are the means for correct judgment curtailed by the reduction of port-space which has been made, but the alternate flashes of intervening smoke and clear sight which constitute the conditions of every Naval engagement, are rendered far more sudden and perplexing, and less capable of being prepared for. In short, the unfortunate "captains of guns" of the "Warrior," with her reduced ports, if not actually "hood-winked," are at least to be forcibly furnished with "blinkers," so as to prevent them from seeing anything but for that instant when it is straight before them; quite as much so as if this "advantage" had been the sole object of the alteration; and there can be no reasonable doubt that the effect of these quasi "blinkers" on the ports must be to reduce in a very sensible, though unknown proportion, the amount of effective fire of which the guns before the alteration would have been capable.

These guns of the "Warrior" are but few in number, and on such few never before in any other ship was so extensive a burthen of defence imposed; but little can they afford, therefore, to have their efficiency curtailed; so that here again we have illustrated how great an error might have been avoided, by bringing to practical test *before its adoption* this specious though very cleverly executed innovation. Had there been in constant readiness an experimental ship, "or anvil," as proposed, in some appropriate section of which an original port, and a reduced port of the "Warrior," might have been fitted side by side, and the guns then worked for a given time under all the circumstances of real action as regards motion of objects, vicissitudes of smoke, &c., a practical value would have been ascertained for this proposal of the "blinkers;" and, when that feature of the proposal had been thus disposed of, then to have ascertained the real effects of shot on the "feather-edge" of an embrasured port would have furnished another datum of true knowledge—how far more valuable in itself, and how far less expensively obtained, than by our present mode of hastily adopting untried experiments on a full scale, and finding out that they must surely be removed, even before they are completed?

But there is a moral bearing in this matter of far deeper import than the mere physical mistake. It has ever been the prominent characteristic of every true Seaman to look his enemy "face to face," and maintain his own traditional superiority by open effort of superior pluck and daring; and are we going to improve upon this quality, or are we tired of it, that we thus prepare to teach "Jack" the new lesson, carefully to ensconce himself in shrinking security, while the enemy he "pots at" is as openly exposed as formerly to all the fair risks of open attack? If so, let us be assured that the true instinct of his courage will bid him neither thank us for such proposed teaching, nor accept it at our hands. So long as British parents continue to produce the children who produce the Sailor, so long, thank God, will it be hard indeed to teach him that a "bloody battle" means but little other than a "bloody nose;" and all arrangements for so making it, however careful and costly, and in whatever ships found, will only be treated as a sign to shun them by all true Seamen, who will feel that they only tend to sap and undermine that instinctive power to cope with every most trying emergency, which the vicissitudes of Naval Warfare have ever afforded to the conscious possessor the means of gratifying, in a degree peculiarly its own.

The one-sided idea alone to be recognised in this reduction of ports, is that of giving some increase to mere "passive protection," to the serious sacrifice of that far higher and more effective principle of protection which consists in providing the most direct means for insuring the destruction of an enemy. But not only does the novelty entail those errors, both moral and physical, I have pointed to, but it seems to have been quite unnecessary for its object. The ports of the new Iron-cased Ships, as well as of the original Floating Batteries of the French, are of the usual size throughout; and in the attack on Kinburn the French Batteries both reduced their ports and angulated their sides to the enemy's shot at the same time by the simple process of mooring the vessels,—not broadside on to the forts they were engaging, but *angled* to that degree which still enabled the entire deck of guns to be used, and with even a more concentrated effect.

The "Warrior" as a Ship of War.

I now come to that main consideration of the subject to which the more general views of preceding Lectures, and the special facts of the present one, have been more or less leading throughout, viz. How far the "Warrior," as the British type of her species, is or is not a true exponent of what an Iron-cased Ship may and ought to be as an Engine of War. But before I submit to open challenge the views I have studiously been led to form on a point of such interest, I desire freely to acknowledge how great is the allowance justly to be claimed for a work at once so novel and so difficult that the ablest professional man would have lost caste as a reasonable being, if found, until very recently, poring over those all but impossible problems, which, solved or not solved, have had most suddenly to be put forth for practical test, under the pressure of irresistible demand, on a scale nothing less than gigantic as compared with the largest of all previous designs for the Navy. I also freely recognise everywhere the evidence of most anxious study and care; but with ears around me still ringing with the strictures I have felt it right to make on so many important details, it would be mere hypocrisy to shrink from the responsibility of openly stating what I believe to be most grave and fundamental errors; all traceable, however, as I think, to the parent mistake of an insufficient preparation for so heavy and peculiar a task; and arising out of an evident but unfounded conviction that, as applied to the structure of ships, there is *no* separate speciality in iron, as distinct from wood, which should require in any degree any special experience in its use, in order to its most efficient and successful application to works of great size and difficulty. And if in this concluding portion of my task I should prove so fortunate as to be held by others also to have established the evidence of this serious misconception as having occasioned the too manifest errors of the "Warrior" and her sisters, I shall esteem all labour to have been amply repaid, in hope that a step may thus have been gained towards a voluntary breaking down of that jealous wall of partition, which for so long has existed as a barrier to both Private and Public advantage; the doors whereof have been used as yet only to exclude what has seemed to those within as "outer barbarism," and the windows only to prevent external radiation of that effulgent light which is said always to glow inside them; but doors and windows both, which, when once frankly opened to liberal intercourse, are destined, I trust, to become future channels of mutual benefit to those on both sides of the Official wall; uniting in the service of a common Country, the willing and zealous efforts of all.

I have already stated the sense in which I shall judge the "Warrior" as a structure of iron; and I now state the sense in which I shall judge her as a "Ship of war." Such Ships in all cases are a combination of the two principles of Offence and Defence; principles which, however capable of a perfectly separate definition in the abstract, are in all such structures so completely blended in fact, that, on the one hand, the most efficient powers of Defence with which a ship-of-war can be endowed, is to endow her—for her opponent's destruction—with the fullest possible powers of Offence; and, on the other hand, whatever defects may exist in her powers of Defence or "protection," must give by so much an increased effect to the offensive powers of an enemy, while equally compromising

her own. In truth, as it is an established principle in mechanics that the strength of any combination is that of its weakest part; and as this principle equally extends its application to military Engineering, so that the effective strength of a fortress is measured by the weakness of its exposed vital portions; so is the same principle as rigidly applicable, and of the same force throughout all that special science of naval Engineering concerned in the construction of those locomotive and floating fortresses called Ships. All alike, of whatever species, whether new or old, of whatever material, come under judgment to the same inexorable law: Whether as to those mechanical conditions for giving correlative strength throughout all parts of the structure, or whether to those having special concern in the projection and repulsion of shot; in either, and in all respects, *the weakest point in any vital portion of the whole combination is the true, and only true, measure of the efficiency for its purpose of the whole machine.*

It is, I repeat, on this view that the consistent advocates for Iron-cased Ships in this Country have ever held that, class for class, from frigates downwards,—the principle being yet young for application to ships of more than one deck;*—no degree of sacrifice or reduction in the powers of Offence, whether in number or position of guns, was, or is, at all requisite for the most complete, not partial, endowment with these newly-recognised powers of Protection; the 50-gun, the 30-gun, or any other denomination of Frigate, as well as Corvettes of every desirable force, being as capable of complete representation, gun for gun, position for position, training for training, under the new description of ships as under the old; increased size and corresponding strength being required in reference alone to the weight of armour. This complete combination of powers of Offence and Defence—of guns on the one hand, and armour on the other—constituting what was ever regarded, and therefore alone advocated by them, as the most complete and formidable ideal of an "Engine of War" ever yet set afloat on the waters.

Such in full are alone the standard or admissible principles in reference to Iron-cased Ships, on which I now proceed to judge the "Warrior;" and I beg further to point out as worthy of very serious note, that such are also the recognised Principles not only evidently held by, but actually carried into effect in all structures of this description put, or being put, forth on the other side of the Channel; not only for our Neighbours themselves, but by them, for the Navies also of at least three other European Nations, who have thus evidently adopted them, and thereby made the British type the sole instance in which laws as old and universally binding as those of Gravitation itself, have been purposely and deliberately violated.

The first and most peculiar feature which is presented to the most superficial observer of the "Warrior," is to find her main battery, permanently, —but we must hope not unalterably,—partitioned off from side to side, into three distinct parts; parts so distinct, indeed, that for myself I have always found it more easy to look, than to pass, through any one of those four little jealous and unaccommodating doors which alone afford access through the iron walls which so sternly separate off each division from its neighbour. But not the several divisions of the battery only; for, with equal sternness and impenetrability, these partitions extend from the upper deck

* This remark, sorrowfully enough, is true of England, not of France.

down to the keelson, separating the entire ship into three portions, having the least possible mutual access between each other; and are in fact those very "box-ends," before adverted to as constituting the "Warrior" into a true iron-coated oblong iron box, having the two opposite ends of a ship of superior form, firmly and very cleverly embodied into, and on to, the two opposite "ends" of the box itself, in a manner which iron would alone admit of; and thus forming out of three studiedly separate parts, one whole ship-form fabric of great elegance, but with an originality, as to mode of construction, unsurpassed, as I believe, by any idea yet conceived, and certainly by any other idea yet executed, as a work of Naval Architecture. But let me here at once remove any impression that these "box-ends" are any true "relations" to that iron bulk-head system which forms the best known means of security against all maritime risks, and is so special a merit in all Ships of iron. These "box-ends" would no doubt fulfil the office of a bulkhead, in respect both to fire and water; but each one contains as much weight of metal as would furnish the requisite number of true bulk-heads for the whole ship; and, though they are of course entirely inside the ship, and equally of course are entirely unarmed with guns, yet they have been built with the same solidity of timber and are covered with the same thickness of armour-plate on their outsides,—*i.e.* on the sides looking to the two extremities of the ship; and are, therefore, evidently intended for the same resistance to shot, as the armed and armoured portions of the "Warrior's" true and exposed outside. But, between these armoured "box-ends" and the respective extremities of the ship, there is in round numbers 100 feet, or one-quarter in extent before each, of the entire length of the ship;—that length "over all" being 420 feet, of which the central armoured portion reckons 205;—and, as these two "ship-ends" are entirely external to, and cover the two "box-ends," it is evident that any resistance to shot which these latter "ends" are intended to make, can only be put to proof after the two former "ends" are either partially or wholly destroyed. And thus, for the first time in the history of War-ship construction, we see a well-studied and deliberate provision made for the destruction of the two extreme quarter-lengths of a magnificent ship—a ship which in cost and anxiety has been deemed worthy the expense of an entire "division" of an ordinary Fleet—and why? strange paradox! can it be because she is also supposed to be the complete exponent of the most complete means of "protection" ever yet conceived as possible?

I have shown in the case of the "Trusty" that no known piece of practical artillery has yet put a shot, however special, through one of her 4-inch plates—loose though they are on their timber support—except at some spot within six inches of an edge; and that, even within these conditions, *the protection of the side itself, under still further exceptional circumstances, was only violated twice in three days' firing.* There can therefore be no great presumption in concluding that the thicker plates of the "Warrior," and their closer fit on much more solid if not thicker backing, supported again by the strength of the ship's iron inside, present a combination of resistance quite impervious to any known artillery of this Country; certainly not excepting the new Armstrong 100-pounder, which, with the same charge of 12lbs as before, but with a shot of 7-inch instead of 6-inch diameter, now disperses its force over a surface of plate one-third

more than before, and is therefore a less formidable gun for penetration than in September, 1859. And thus to all who fight *within* the walls of the "Warrior's" iron box, there is a guarantee of personal security to an extent never before even contemplated in any Naval Construction.*

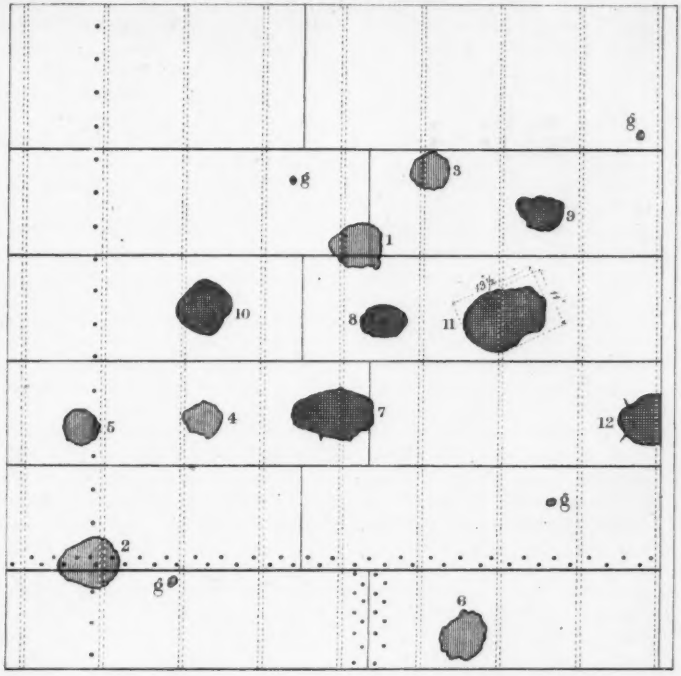
But I have also shown, and will now endeavour still more forcibly to impress, how great is the contrast, nay, how entirely reverse are the circumstances, in respect to those two divisions of the battery which respectively are external to the two "box-ends," and where the amount of protection afforded is solely that which is furnished by iron plating $\frac{5}{8}$ of an inch thick. Pray let me neither misrepresent, nor give cause for misrepresentation. As in all ships whether of wood or of iron, additional strength is, I know, also given to the sides of the "Warrior" for a cercertain distance above and below the line of beaming on each deck, and the "waterway" and "shelf-piece" of her main-deck battery are made for this certain distance of a double thickness of $\frac{5}{8}$ plate; but neither this nor the fact that for another certain distance, before and abaft the ends of the armour, there is also a double-plate thickness, makes it an error to state in the usual terms of description that the main-deck sides of the "Warrior" beyond the "box-ends" each way, like the same sides "throughout" of the "Birkenhead" of 1843, the "Simoom" of 1845, and the "Himalaya" of 1851, are of $\frac{5}{8}$ plating only. And if there be no marked superiority, which it is not pretended that there is, between these $\frac{5}{8}$ plates of the "Warrior," and those representative ones of the "Simoom" of the same thickness, which were fired at in 1850, then the diagram of No. 2 plate, to which I now refer, truly represents what must be the effects of all shot, down to grape-shot, on those two terminal quarter-lengths of the "Warrior," divided off by the armoured "box-ends;" and shows that to all who fight within this $\frac{5}{8}$ protection only, and *without* the walls of the "iron box," there is also guaranteed an amount of personal *insecurity* never before even contemplated in any Naval Construction intended for serious War.

Let me again guard against misapprehension in saying this. In former Lectures I have, I know, as it were, boasted that the Ship-of-iron was always as capable as the Ship-of-wood to bear the brunt of action; but it will be seen on reference that this claim, wherever made, has always been based on the shell-proof power of the Ship-of-iron, which discovery was made simultaneously with that of the "splintering" of the shot; and even at that time Civilians could also see and complain that the power of the plates which could thus "break up" the shot by a first resistance, was not, as it ought to have been, employed a second time, by an "inner lining" of the same plates, to stop altogether the splinters thus made; and we may be thus assured, that had the "Simoom" not been perverted from her original design as a frigate, she would never have gone into action with sides of a *single thickness* of $\frac{5}{8}$ plating, as those of the "Warrior" and her sisters now are.

I will not, then, tire you with reading what splinters were produced by each shot, and what these splinters did; I will only proceed to read the description of each shot, and the size of hole it made, in the remote hope that some unabsorbed Member of the Legislature may thereby be led to examine for himself, and bring to the notice of his brethren, a record (No.

* As the timbering of the "Warrior," unlike that of the "Trusty," is distinct from the strength of the iron-side proper, it is possible that this side, like that of the "Erebus," might be found to "give" or bend under heavy fire.

Effects of Shot on 5/8 Plates, similar to those of the "Warrior" and Sister Ships.



Scale of Feet.

"Rear Admiral Chads stated in a letter to the author
"that out of seventeen 32-pounder shot which struck
"the iron butts at the distance of 450 Yards with
"charges varying from 2½ to 10 lbs. sixteen were
"shivered to pieces on passing through the first side
"and became a cloud of langrage too numerous to
"be counted."

See Naval Gunnery 5th Edition Part II. page 126.

"It will be observed that all descriptions of shot from the 10 inch
"down to Grape have been used and all with similar destructive effect"
See Report of 21st June 1850. in 737 of 1850. page 9.

Explanation.

The Holes made by 8in and 10in Shot are shewn thus .....

" Holes " 32 lbs Shot ..... Do .....

Holes made by Grape Shot

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737 of 1850) specially demanded for their own information, and containing a "conclusion" from unquestioned authority with respect to these holes and splinters, as truly applicable to the "Warrior" of to-day as to the "Simoom" of 1850: viz. that "the large irregular holes would be most destructive;" and, in respect of the splintering from the plates,—that "I firmly believe men could not stand behind them."

No. 1. 32lb. shot. Charge, 6lbs. Hole, 9¼ inches by 8.
No. 2. 32lb. shot. Charge, 6lbs. Hole, 11 inches by 9.
No. 3. 32lb. shot. Charge, 6lbs. Hole 7 inches in diameter.
No. 4. 32lb. shot. Charge, 2½lbs. Hole, 10 inches by 8.
No. 5. 32lb. shot. Charge, 2½lbs. Hole, 6½ inches in diameter.
No. 6. 32lb. shot. Charge, 10lbs. Hole, 6½ inches in diameter.
No. 7. 8-inch hollow shot. Charge, 10lbs. Hole, 15 inches by 9.
No. 8. 8-inch hollow shot. Charge, 10lbs. Hole, 8 inches by 6.
No. 9. 8-inch hollow shot. Charge, 10lbs. Hole, 8 inches by 6½.
No. 10. 8-inch hollow shot. Charge, 3lbs. Hole, 10 inches in diameter.
No. 11. 10-inch hollow shot. Charge, 12lbs. Hole, 13½ inches by 11½.

The holes of the five larger shot are bordered with red.

The four smaller holes, 3 inches in diameter, and lettered with G, are of 32lbs. grape-shot, with a charge of 6lbs.

The range throughout was 450 yards.

Whether double thicknesses of $\frac{5}{8}$ plates, where they occur, are or are not penetrable by grape-shot of the same description as the above, or, indeed, by any other, is utterly unknown; for, amidst the many worse than useless experiments which have done nothing but perplex the last three years, not an ounce of powder has been wasted in ascertaining a matter so unimportant and inapplicable to the present time; but of this we may be quite sure, that the shell-proof power of $\frac{5}{8}$ plates, which undoubtedly existed in 1859, and alone justified, if anything could, their use in such ships as the "Warrior," exists as undoubtedly no longer; and the place in these Lectures has been now arrived at when it is necessary to point out that all the arguments used by me on the strength of Sir Howard Douglas's perfectly true "conclusion" that "$\frac{5}{8}$ plates are shell-proof," were applied only to circumstances occurring prior to 1859, and before any general introduction of rifled cannon had changed the form, and with it the important question of "penetration," from that of spherical shells, to that of conical ones. And here, again, not an ounce of precious powder has been wasted in informing us to what extent this change has deteriorated still further, that minimum of protection originally accorded to the two quarter-lengths of the "Warrior's" battery. We know that in the rival "Warriors," if not throughout the entire Naval Service of our great Neighbour, the spherical has been replaced by the conical form of shot and shell; but in our sudden and absorbing interest in all matters concerning "thick" plates, we seem altogether to have overlooked the fact that we have so constructed our own "Warriors" that their very existence in action, with all which composes and belongs to them, depends on the destructibility,—not of their "thick" plates, but of their thin ones. It may or may not be, for nobody in England knows any thing about it, that the conical shell, like the spherical, will be "broken up" against

the "Warrior's" 4½ plates, either of single or double thickness, and its powder, as before, be scattered to the winds outside; but from all that I have seen or heard of conical shell firing, I am led to believe that the shell-proof qualities of those sides has, in reference to this change, *entirely departed from them*, or even if the conical shell be still liable to be broken by these plates at all, it may be so to that limited extent only which may still enable the charge to be exploded inside the ship.

Again, with respect to shot, will the 4½ plates "break up" those of conical form, as in 1850 they so inexorably did the sphericals? If not, how will this change affect the men and material within the two end divisions of the battery? Will there be a reduction of fatal splinters from the plates, so that "men" may now be expected "to stand behind them?" or will the entry of whole shot, instead of splinters only, break up more of the inside material of the battery than before, such as gun-carriages, &c. and thus keep the question of splinters, and personal loss from them, very much as before? Is there in England neither gun, gunner, nor gunpowder; or is it true, as rumoured, that she has no "established" *conical solid shot* whatever as yet determined on, that questions so vital to her pet Champion should have to be so universally answered by a shrug and a "don't know"? But what I think we do know, is that, except as regards lodgment in her side, the "Warrior's" end batteries are as liable to combustion by the Martin shell as the batteries of any wooden ship. There is the very thickness of plate just sufficient to break the wall of the shell; and we may certainly conclude that the contents when thus freed will not, like the gunpowder charge of the spherical explosive shell, so obligingly remain outside; and when inside there is the broad spread of teak deck with its pitched seams for those fiery contents to take effect on; there is the 2-inch teak lining of the side which covers the iron frames; the light bulkheads of the after cabins; the mizen-mast; fore-mast; bowsprit; &c., all offering fuel to fire. But, above all, there is that 2-inch inner lining of wood, with its wooden bottom, or "waterway, provided, as if purposely to receive the molten metal of the shell when first broken, and presenting the most convenient possible lodgment, short of a complete wooden side, which Mr. Martin himself could reasonably require for testing his power to burn a Ship of iron. Might it not also be remotely desirable to try if Mr. Martin's projectile will or will not distribute its liquid metal through ship-sides built of 4½ plates?

But this friendly lining offers a further service towards heightening, if possible, the more than contrast between the fighting capabilities of the respective divisions of this most unique of frigate batteries. It is fixed to the inner angles of the iron framing by nothing more substantial than wood screws of suitable size, so that to every sort of missile, except one, which may enter through these thin plates, it presents, as it were, in eager readiness, as much of its substance as the missile can conveniently use, from a whole plank to only a fragment of one, towards adding spinters of wood to those of iron. For this wood "lining" of the "Warrior's" main deck is not to be mistaken for the substantial timbering of the "Simoom's" iron side, which is described in the account of the No. 2 target of 1850, as "the inside timber of a frigate:" this "lining" is attached only to the interior edges of the framing, and leaves a 10-inch space between it and the ship's iron side: it does not therefore, and is not intended to, add to the strength

or resistance of the side, as the "Simoom's" timbering did, but is ornamental only, and its only appreciable use, besides that of fuel, is, as I have stated, to supply splinters of all sizes to missiles of all sorts except one. And the case of this only missile, which will not be able thus to use this lining, will perhaps furnish a more forcible illustration than all others I have specified, of the extent of personal protection provided for those who do *not* fight within the four privileged walls of the "Warrior's" central iron-cased box, but who *must* fight,—so long as they are able—in those two extramural and unprivileged portions of the same deck; so that others may, by this illustration, judge whether I have or have not justly characterised the condition of these two portions, as "*guaranteeing an amount of personal insecurity in action never before even contemplated in any Ship intended for serious War.*"

When Mr. Whitworth places a small steel bolt instead of a leaden one over the ordinary charge of his ordinary rifle, an iron plate $\frac{6}{10}$ of an inch thick is no security against a fatal shot from a distance of 40 yards; and who will venture to say, much less to try, how few more grains of powder, if any, will be wanted in order to fire an equally fatal shot from the same distance, with the same weapon and bolt, through that fractional increased thickness which exists between a $\frac{5}{8}$ and $\frac{6}{10}$ plate of iron? Thus, a person standing half in and half out of one of those jealous little doors of separation, would be secured on the armoured side of the bulkhead from the fullest effort of the most powerful known artillery; but might be shot to death by a mere "small-arm" though that contiguous portion of the same side, which has thus been made but little less penetrable than if built of "papier maché" instead of iron at all. And if conditions of such extreme contrast in "efficient" and "deficient" protection between such large and vital portions of the same battery, in the same "floating fortress," when under the same fire, be indeed a *necessity* of Iron-cased ships, I for one must believe that there could be no great risk in holding our hands, and buttoning our pockets, until some more venturesome and affluent Nation had first proved the difference between the *real value* and *monstrous cost* of such impossible and unheard-of incongruities.

So much then for the "physique" of this invention of the cross bulkheads, or "box-ends;" but before proceeding to bring its "morale" to test also, it may be well to try and examine if there be indeed any *necessity* for this invention at all; or rather, whether, by converting a mere ideal crotchet into an actual substance, those very conditions were not then first created, by appeal to which its "necessity" could alone be defended AFTERWARDS. It is claimed as a special proof of the "high science" displayed in the construction of the "Warrior," that the displacement given to the central box is such, that when the two separate ends, which alone make her a ship, are destroyed, the centre will still remain afloat with the wrecks attached to it; and for the first time in her English life, High Science has thus been employed by Naval Architecture to assist in making provision, not against any injury to, but for the certain destruction of, about 100 feet in length of each of the two ends of one of the largest and handsomest ships she ever saw built in this, or any other Country; the particular object being to save from "sinking" that which, but for this "highly scientific" display, ordinary mortals, ignorant of true "Naval Architecture" would have thought it most desirable to preserve from any approach towards a sinking

state. Nevertheless, the exact extent of how far the destruction should proceed, and no further, was made a matter of deep study and calculation between the two parties, which, when successfully accomplished, was also a matter of evident and common delight. But how was the "destruction" itself to be accomplished, which should thus prove how correctly High Science could be applied to this very interesting problem in Naval Architecture? By means of the guns of an enemy, of course. And how was this again to be provided for? Oh! very simply, just by making the portions intended to be destroyed so very much more destructible than had ever been done before in any other ship—so much so, indeed, as to enable even a rifle bolt to be employed in the work,—that the very first action the ship should be engaged in, the exact calculated amount of destruction, no more, would be sure to take place,—nothing whatever to prevent it. Now, Naval Architecture, with the aid of High Science, having thus so unmistakeably provided for the object in view, let us suppose this pleasant arrangement to have been overheard by the unfortunate "Warrior" herself, who, in great tribulation, at once engaged Common Sense to plead with Naval Architecture,—not Naval Architecture in general, be it understood, but only that particularly great branch of the art which claims to be alone capable of producing "Warriors,"—against this very sublimation of all which is "highly scientific;" perhaps in some such terms as these. "In my own plain humble way, not being in the least "scientific," but only desirous of fighting a first-rate battle whenever required, to the credit of both my Owners and Masters, I can't for the life of me see what's the use of so carefully providing for both my ends being destroyed, in order to show how cleverly my middle has been proportioned to carry the wrecks of them afterwards. For my part I believe, when once my ends are gone, the sooner the middle goes after them the better, as I cannot then possibly defend myself, but must lose all power of motion, and all power of directing it, if any had remained, so that the capture of my disgraced hulk is sure, and can only add to my own shame, and the ridicule of all who had a share in making me. Besides, I thought I was to be the first British-born Iron-cased frigate, which meant, I was told, that I was to be protected all over from every sort of shot and shell whenever I went into battle; instead of which here's no less than 200 feet of me, which itself is longer than any other frigate, that's altogether been made far more destructible than any part of any other fighting-ship ever was before; and nobody will be fool enough to waste their shot and shell on my thick-plated middle, when there'll always be one or other of my two 100-feet ends to fire into; both of them so wretchedly thin and shivery, that one of Mr. Whitworth's steel bullets can punch a hole clean through my side. I plainly see that I've been victimised in order to carry out that crotchet of making an 'iron box' instead of an honest ship of me; and those who made me so ought to have had more of your kind of Sense than to have taken so much pains to do what it was just their proper business to prevent as much as possible from being done at all. If they don't put back again on my thin sides all that weight of iron they took off them to make those 'box-ends' with, and so keep the shot and shell out of me altogether, I know very well what must become of me the first stiff fight I'm taken into; and then won't 'Owners' talk to

'Masters' about trying their 'high science' crotchets upon such-like ships as me."

For obvious reasons, as well as in charity to that model Institution, already so deep in other mire, I withhold from transcribing more of this open appeal to Common Sense, which even the wooden "Warrior" could see, was her only chance of escape from terrible disgrace; and agreeing, as I do, with almost all she said then, and with a great deal of what she said after she got a little bit warm on it too, I beg to submit my own more quiet convictions in support of her angry tones, and exhibit what is the evident *morale* of this remarkable experiment.

If there be in our language any one sentence embodying that special bond and sentiment of common effort in weal or woe which unites all, of all ranks and ages, in the performance of all duty, of peril or enjoyment, throughout the varied services of our Navy, it is the simple expression, SHARE AND SHARE ALIKE. It is this which is ever present to mind, ever pleaded, ever acknowledged as of paramount force, in all appropriate circumstances; and there never is, never has been, and I trust never will be, a thought of appeal against its overruling decision. It represents the basis of all true discipline, as of the just exercise of all authority; it not only presides at every meal of every day, it presides in every preparation for them, so impartially, and so entirely without exception, that when within the four walls of one of Her own ships, and as if to take lead in this common and daily consecration, our great and good Sovereign herself, with all surrounding her, most graciously submits, in this special particular, to its universal claim of allegiance. But, in all cases, as the greater the peril, so the greater the honour of distinction, and the more unswerving the instinctive demand for "share and share alike." And is it to be supposed, even were it ever so desirable to attempt, that the difficulties presented to the fulfilment of this unexceptional demand by such arrangements as now chacterize the fighting decks of the "Warrior" and her sisters, would suffice in actual battle to dethrone for the first time or even to control the universally acknowledged power of this principle of chivalrous justice? Most assuredly they will not; like a true instinct, as it is, it will in such case, which I trust may never be proved, but become the more imperative for opposition; and the very earliest period of battle which proclaims that the paramount brunt of danger is to be borne by all those who occupy one part of the common deck; while all but entire security is to be the fixed condition of all those who occupy another but contiguous part close to it; will produce between these two cruelly separated portions a human circulation as true, and inevitable, and uncontrollable as the power of the atmosphere when restoring its wonted balance. The first direction which this opposed instinct will take will be of course towards overpowering the opposition, for which the readiest means at hand will be the two guns nearest inside the bulk-heads, with which to blow them away; and so open a free access of support *to* those who are furnishing all the slaughter *by* those who are furnishing none; but, as this measure might not be effected without several shots, and a serious increase of risk to all, a more limited access would have to circulate through those four little iron-bound doors of "separation" on which, in such a scene, the everlasting lines of Dante would find an application more real than the great Poet in his fervour probably ever imagined; for, as gun's crew

after gun's crew went down or were disabled in the unprotected portions of the battery, so would they,—must they,—be replaced by those from within the armour; and even those who had stood the brunt of exposure for a given time and still were standing, would have to exchange places with those who had only fought hitherto in privileged safety; so certainly would the true instinct of "share and share alike" enforce the fulfilment of its yearnings in the heart of every true Seaman, Officer and man alike, if ever placed in such fearfully trying circumstances. And if it were not so, which may God forbid, how should each survivor, whatever the issue of the fight, meet friend or messmate face to face again; how describe, how speak of, how allude to, how even think about common perils;—still less how dare to dream about sharing common honours, under a consciousness that the station of passive safety during the whole strife had never been forced, never urged, never offered, never been intended to be offered, to any—"share and share alike"—in exchange for the station of death?

But if the heat of fight would thus supply to the great body of combatants some self-acting compensation against the arrangements for paralysing, as far as possible, all concert or community of effort throughout the batteries of these powerful frigates when in action, there would still be one party, having a special interest in the battle and its result, to whom no such relief or compensation would be open. The "Warrior's" noble battery, of 19 guns on each side, will be provided with crews of (say) 20 men and boys for each; the central "box" taking 13 such crews, and the extramural portions three each; 260 in all within, and 120 outside the walls of the divisions, besides the proportionate Officers on both sides; and with any prospect of that battery coming into actual battle, I can conceive no position of responsibility attended with conditions of such harassing pain as that of the Authority who must peremptorily assign the one or other side of those bulk-heads, with their perfectly known contrast of consequences full in his mind, to those who must respectively there fight. Yes, "fight courageously!" such are the terms of the Draconian, but requisite, law in which "under pain of death" a Captain upon prospect of any "fight or engagement" is required to encourage all Men and Officers under him. But who could be calm and self-possessed for meeting his coming trial, as he passed in review those separated sets of crews, and noted faces of men and Officers, recalling events in Naval life and discipline and personal character connected with those before him, to whom his sole power and award had allotted stations in the coming strife so utterly the reverse of "equal shares in an equal peril;" and that award again so fearfully capable of being attributed to motives the most abhorrent. Would it not be the mind most conscious of a just exercise of authority which would most be shocked on recognising in the one or other side of those truly fatal partitions the well-known features, whether of officers or men, most frequently obnoxious to his awards of correction, or most frequently claiming his approval and regard?

But I need not dwell longer on so painful though inseparable a feature of the very serious error I am reviewing, because enough has been already said to show that these divisions of batteries cannot be maintained; and because it is certain that England never intended, and at whatever cost will never permit, that those who go forth to fight her battles in Iron-

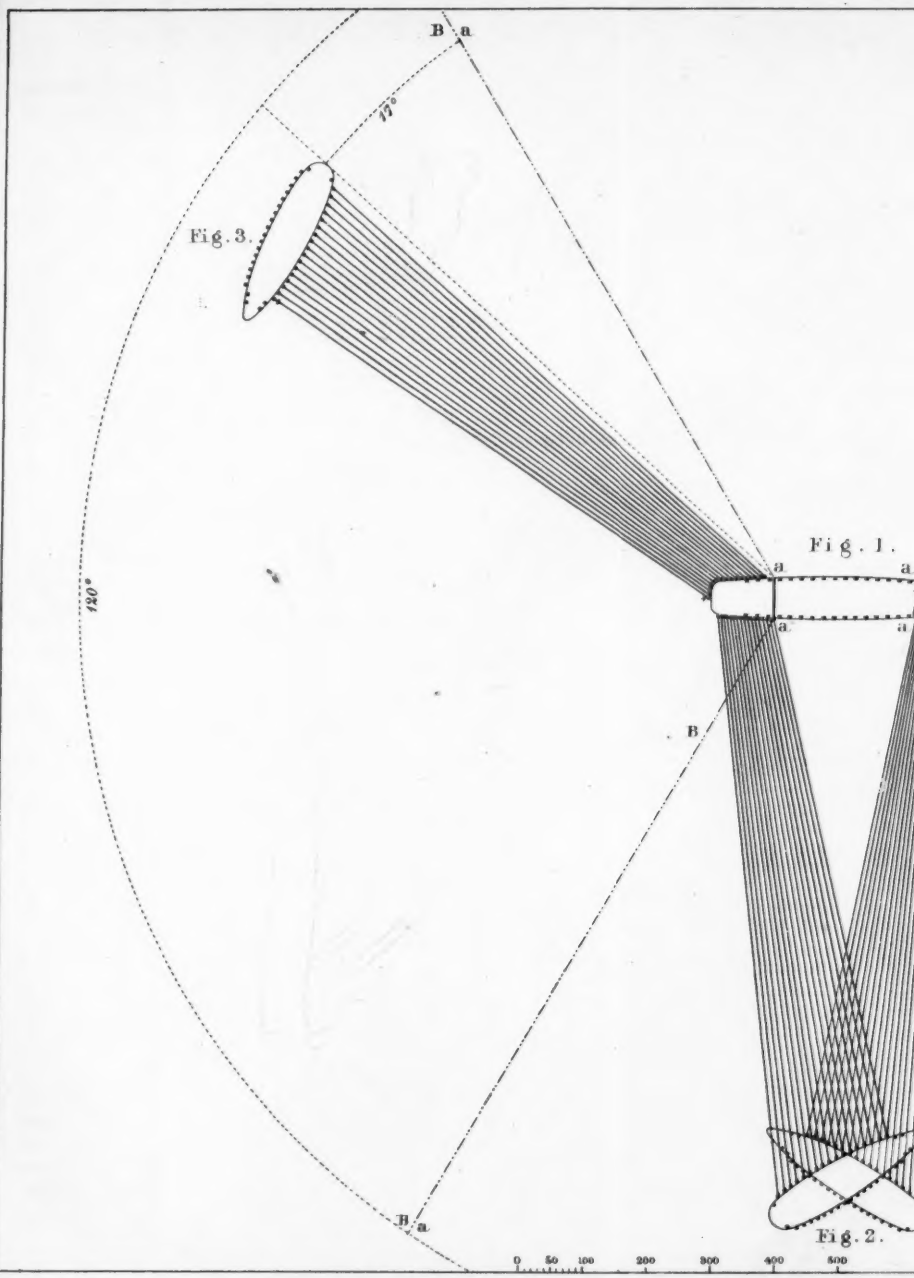
cased Ships should, one and all, be harassed at the very moment of trial by a struggle of feelings quite unparalelled, and solely due to arrangements which are as utterly unnecessary as they have hitherto been totally unheard of. I therefore hasten to bring them to test by showing what must be the inevitable consequence of providing our Iron-cased ships with a "Partial" instead of "Complete Protection," lest unfortunately a Principle so untenable should ever come to be put to fatal proof by an enemy.

In doing so I will endeavour to spare our cherished notions of the "Warrior" as much as is consistent with an honest discharge of my task; and for her own special consolation we will borrow our neighbour's "Gloire" for the purpose, but make an English "Glory" of her, with British hearts of oak, or iron—if you like,—for Officers and Crew, in similar proportions to her armament, and in every requisite qualification equal to those who shall fight the "Warrior." But she shall still retain her 17 main deck, and 2 upper deck guns, all protected, as well as the ship throughout, with armour as impenetrable as that of her opponent; their description being, as stated, the well-known French 54-pounder, rifled to throw conical shot and shell, the former of 80lb. weight. Her masting; her engine power, her stated speed of 12 knots, and length between perpendiculars of 252 feet; shall all remain as now. In both cases the entire Engine-power shall be assumed as applicable to the purposes of steerage; but, as the "Glory's" proportion of power to length of ship is greater than the "Warrior's," and as she is 133 feet less in length, she cannot be deprived of her evident advantage in "steerage power," or the means of turning; which may be assumed to be compensated for, as far as it can be, by the 2-knot superior speed of the "Warrior." With these preliminaries fixed, and the same angle of 30° each way given for training the guns of both ships, the sole condition of battle shall be the determination on both sides to fight—"*à l'outrance*" if you will.

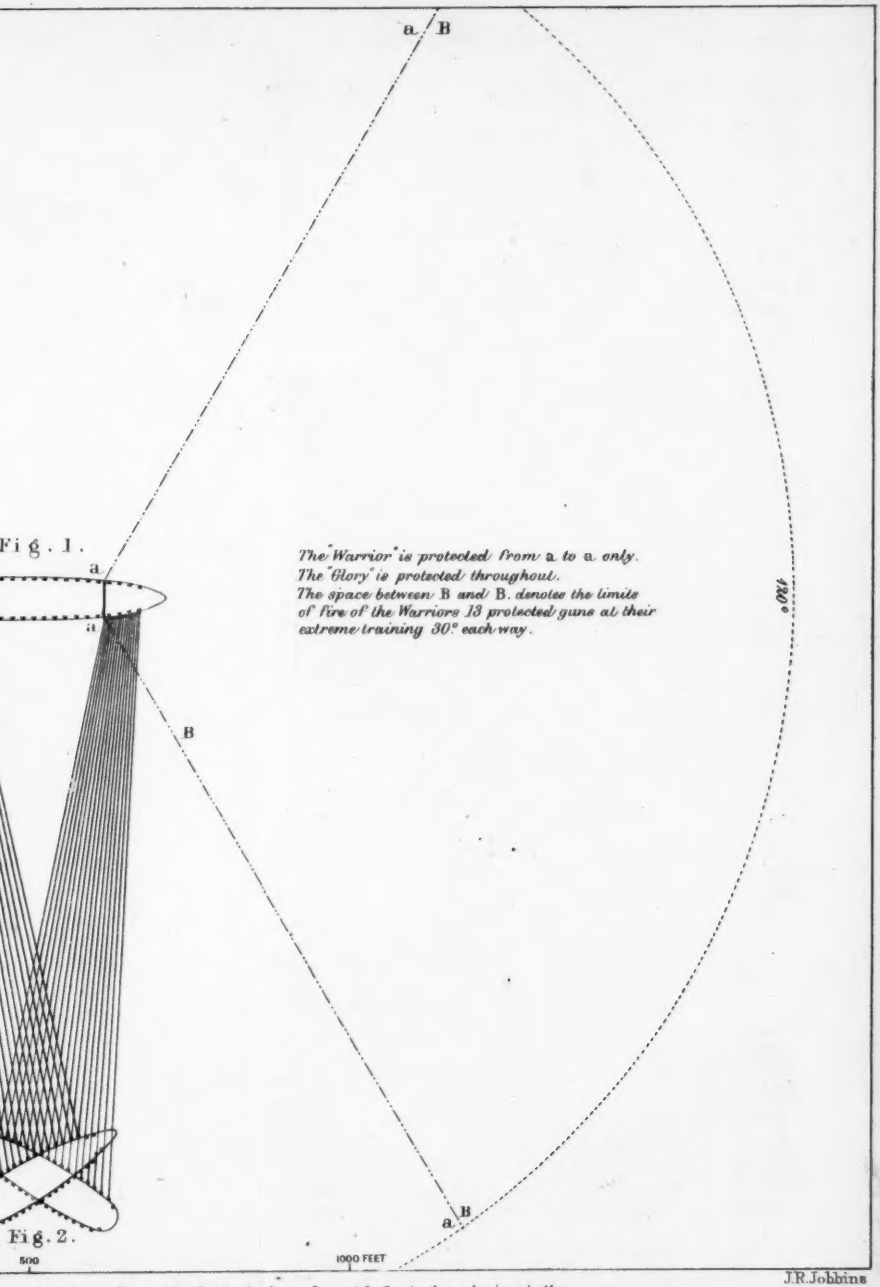
There can be no occasion for proceeding to confuse either myself or others by any lengthened professional detail of the relative positions of this or that value which may be taken on either side, their name, doubtless, would be Legion; but, with the full statement already made of the "Warrior's" fatal defect, and the fact that her construction with such large portions of absolute weakness was quite intentional, though of course not recognised to be "defect," it must be obvious that all manœuvring between ships which so completely illustrate the two principles of Complete protection in the one case, and only Partial protection in the other, can have but two opposite objects in view; the one to concentrate her fire at all times and as heavily as possible on her opponent's points of weakness, the other to present these points of weakness as little as possible to the guns of her opponent, and to bring her beneath the effective fire of her own. The prosecution of these objects, and the limited distance to which the shot on either side will be effective on the armour, will determine the action to be a close one, which will offer to the "Glory" her best chance of taking a position formidable to the one or other of the "Warrior's" weak points; will make her fire most destructive while in that position; and will best enable her to keep it; to which her ability of quicker turning will also further conduce. Such a struggle therefore will have the general feature of making the "Warrior" the attacked, rather than the attacking party, and will give on both sides a far greater importance to the

relative powers of "steerage" than to those of speed. Those powers are the sole means by which the "Warrior" can hope to bring all her own guns to bear on her enemy; but no powers of steerage, however superior, could avail to keep her weak points from under fire altogether, they are far too extensive and prominent to be ever out of fire whilst within range; and the utmost that can be done is to present them in the position least favourable for that eventual "destruction" which has been but too completely provided for. For instance, as in Plate 3, figure 2, let us assume for one relative position the "Glory" laying right abreast of the "Warrior," under the fire of her entire starboard broadside at a distance of 370 yards, her own head kept pointed towards the "Warrior's," but at an angle of 30° across her line of keel, in which position she would concentrate her own port broadside entirely on the "Warrior's" aftermost 100 feet, careless of all other reply to her opponent's guns; the shot of which she would thus be receiving, *à la Kinburn*, on angulated sides and reduced ports; and be quite content to continue so receiving them in the full certainty that she was still giving far more injury than she was taking, as would soon appear by the silence of those three after-guns of the "Warrior," covered as they are with a protection less than that given in 1845 to the side of the "Simoom." And when this notice was given of the effect made on the "Warrior's" aftermost 100 feet, then on her part the "Glory" would be quite content, as shewn in the same figure, to continue receiving the fire of the remaining 16 guns of the "Warrior's" starboard broadside as before, with her own head angled as before, but changed in direction so as to point towards the "Warrior's" stern instead of head; and with the whole of her own starboard broadside concentrated on the "Warrior's" foremost 100 feet, until her three foremost guns had in like manner been silenced. Nor would these results be changed, except in time, were the distance to be increased to say 1,000 or even 3,000 yards, all other relative circumstances remaining as before. In such case the "Glory" would still have the option of concentrating her fire on whichever of the "Warrior's" two unprotected ends she might choose; the mizenmast of the one, and the foremast of the other, giving the direction of fire at all distances, as completely as if intended for the purpose. The superior speed of the "Warrior" would doubtless at all times give her the command of distance, though not of position in close action; but this command would be of questionable benefit; for, if used to extreme, the shot of the "Glory's" guns at their most distant range would still be effective on the two weak ends of the "Warrior," as witness the Woolwich experiment of 1845, where the smallest quantity of powder still took the shot through the $\frac{5}{8}$ plate; as also the experiment on the "Simoom" plates of 1850, where the shot from a boat's 24-pounder carronade fired obliquely still made a long oval hole; while, on the other hand, the strongest advocates for the spherical 68-pounder admit that after 400 yards their pet shot loses its power of "smash."

The "Glory" would thus always have the option of attacking the one or the other of the "Warrior's" unprotected ends, and she could have no difficulty in choosing which. The foremost end covers nothing vital beyond the foremast and bowsprit; but, besides the mizenmast, the wreck of which would be the most likely to foul the Screw, those after $\frac{5}{8}$ plates are all the protection which covers the rudder; both yokes; and the four sets of tiller ropes; if not the four wheels which work them; and is therefore by far the



Note. *The Glory is supposed to be using from her main-deck battery of 17 Guns,*
three with Martin's incendiary shells; and four with spherical shot to make
The fire of the "Warrior" is not shown solely to avoid confusing the diagra



The "Warrior" is protected from a to a only.
The "Glory" is protected throughout.
The space between B and B. denotes the limits of fire of the Warriors 13 protected guns at their extreme training 30° each way.

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y of 17 Guns, five with Conical shot; five with Conical explosive shells;
hot to make splinters with; thus reducing the Warrior at both ends to a mere wreck. See plate 2.
a the diagram.

most vital of her two unprotected portions. It is for this reason that in figure 3 of the same Plate, to which I now refer I shew the "Glory" as having obtained the most formidable position for the speedy destruction of her enemy which is open to her; not that I assume her power to take this position whenever she chooses; but in action between ships under steam the taking of position will be far more a matter of choice, and far less a matter of accident, than with ships in action under sail only, although for the same reason—viz., that of possessing self-contained power of motion—a favourable position may not be so long held. The power of the "Glory" to keep that fatal position to the "Warrior," in which the diagram shews her, depends on her own combined powers of speed and steerage. So long as the "Warrior" should try to steer round upon her opponent, so as to get her unprotected stern "out of Chancery," and give full effect to her own port broadside, the "Glory," in order to maintain her position, must, theoretically, steam round a circle, the centre of which would be the "Warrior's" pivoting point, and its radius the distance from that point to her own centre of gyration; and this circle she must steam round in the same time as the "Warrior" "pivoted" round the circuit of the compass. But practically, the "Warrior" herself must steam round a circle, as she could not pivot as on a fixed point, and the "Glory" therefore must steam round an outer circle with a radius of 370 yards more, completing it in the same time as the "Warrior" her inner one; and, as the relative powers of the two ships forbid this expectation, the "Glory" would gradually lose her position of advantage, as shown, though not without ample time for some two or more broadsides, which, if well delivered, might go far towards hastening the ultimate issue. On the other hand, if the "Warrior's" inferior steerage power, or any injury to it, should disable her from coming round faster than the "Glory" could keep pace around her, then her only resource for breaking away from the death-grip would be by using her superior speed to a certain distance "right on end," when the battle would come to be renewed again under a fresh series of positions, always struggled for with the same inevitable objects in view on both sides, and always with the same inevitable disadvantage to the ship with so great an extent of exposed weakness as the "Warrior," when compared with an opponent which had none.

Let us now reverse the names of the occupants of the two respective positions in figure 3, and compare the advantage it would give to the "Warrior" with that which the "Glory" would derive from it; when again the terrible difference between a protected and an unprotecterd stern, exaggerated to a length of 100 feet into the body of the ship, would become as apparent as ever. There would be the "Warrior's" chance, no doubt, of the entry of her shot into her opponent's ports, but that is still her only one, and would exist to no greater degree, *if so great*, as when broadside to broadside. Her shot would be received, not only on the highly angled sides, but on that curvilinear stern of her opponent so admirably formed to give effect to the invaluable principle of Shot-deflection, which has been to the same degree so entirely despised in the construction of her own. The rudder we know is fully included under the protection of that stern, so that it is difficult to see what positive advantage she would gain at all by taking a position which, when held by the "Glory," was so fatal to herself. The negative advantage of the position to her would consist in the smaller num-

ber of the "Glory's" guns which could play on her own devoted stern, which negative advantage the "Glory" would, of course, in prosecuting her own unflinching object, allow her the benefit of for as short a time as possible, and her more effective steerage powers would enable her to displace the "Warrior" from the relative position far sooner than she herself had been displaced.

A maximum of the above negative advantage to the "Warrior" would, no doubt, accrue from her taking a position at right angles, and right across either the stern or the bows of the "Glory," for in those positions few, or none possibly, of the "Glory's" guns would bear on those two fatal extremities; but, as before, she could not hold such positions long, and if she could, "Complete protection," as compared with "Partial protection," would only the more fully exemplify the difference between them, by refusing to yield any positive advantage while holding such positions, beyond the opportunity of wasting shot or shell on such highly angled bows; or beyond a shot occasionally entering at a port, if lying across the stern.

The Plate as shewn was not intended to deprive the "Warrior" of the twelve guns in her extramural batteries, but, as it was desirable to exhibit the two entirely opposite Principles, as yet adopted by the one Nation and the other for their respective Iron-cased ships, it was thought best to distinguish as much as possible the unprotected from the protected portions by exhibiting the 13 protected guns only. The angular distance shewn in the diagram which the "Warrior" would have to "come round" before the aftermost of her protected port guns would bear on the "Glory's" port quarter, is two points of the compass; but the curve of the ship's form has not been taken into account in angling the line of fire of the "Warrior's" guns, which if done would shew them to cover a somewhat greater portion of the "limits" within which she is exposed to fatal attack; but to which in truth she is more or less exposed, and at every distance within range of every gun, from that most fatal position shewn in figure 3, to the assumed one of right athwart bows or stern; and thus I have sketched as it were a skeleton of positions which any one may fill in according to fancy for himself; but which must always exhibit the fatal defects of "Partial protection." The distance shewn in the Plate between the two ships is 270 yards, or, say twice the "Warrior's" length, as a convenient distance to avoid boarding, but I need not dwell on this perfectly speculative operation, for which no description of ship more than another is ever specially built. Neither need I notice the operation of "ramming," as it is jocosely named, for ships will require indeed a very special construction when such an operation if at all possible, is provided for, and certainly "papier mâché" ends, like those of the "Warrior," won't be among the requirements.

But there are more "Glorys" and "Warriors" afloat than the two which have now been battling; let us add a consort on each side and try again. Alas! there will then be *two* unprotected bows and *two* unprotected sterns to be kept out of the way of two completely protected and hungry opponents, who by a little obvious combination will be able to secure the same fatal issue sooner than before. A double exposition of weakness affords no compensation or consolation for a more limited exposure; and no multiplication of false principles can ever produce a sound one. While to talk of such ships as the "Warrior" taking position "in

line of battle," with many enemies around, and all of far greater force than herself, is but to add insult to that which is sorrowful enough as it is.

But how about opponents of wood? With her superior speed, when with a clean bottom, the "Warrior" would no doubt be in safety in presence of a 12-knot 90-gun ship; and, at long balls, might do her injury; but, if within range herself of those 45 guns, she must expect, with a mizenmast and foremast again to mark her weak points, to get quite as much as she gave; and must give up any chance of advantage by getting into effective shell-range. On the other hand, her "Partial Protection" in such a presence would place her in a position so little more advantageous than that of a frigate of wood, that she must fall a prey, quite as certainly, and almost as soon, if by accident the "ship" should ever close within half range of her.

How, then, about a frigate of wood, an "Orlando," or "Emerald," with a 25-gun broadside to her own 21? Here her superior speed would give her the option to fight, which she could not refuse; and the amount of her protected guns would bear a far more favourable proportion to those of her adversary than in the former case. But, still, those terribly tender ends! and especially the after one. If, in close action, the frigate should succeed in taking the position shown in the figure 3, and could keep it long enough for a few well-delivered rounds from each of those 25 guns, then I presume to no powers of prophecy whereby to determine the issue.

As I am specially judging the "Warrior" as the British exponent of what an Iron-cased frigate should and may be, in respect to her relative merits in action with ships of her own description, these two latter cases need not have been put at all, except that in casting down such a challenge as I am quite conscious that I now do, I desire to show that in all points the case of Principle I submit has been as closely examined as I am able. These two cases, however, enable me to point out that the battle with the "Glory" was purposely fought out with cold shot only; yet I am myself well convinced that $\frac{5}{8}$ plates, whenever proved—with many more 8ths added to them—will be found perfectly penetrable by live conical shells, both time-fused and concussion, as well as by the contents of Martin's most formidable projectile.

The detail of all these cases of assumed contest will also, as I trust, have gone far to impress others with my own conviction, that no man will waste a blow where he knows it cannot take effect, in preference to directing it to where it must take the fullest effect he can wish for; or, in other words, that, *except as a mistake*, not a shot or shell from any opponent, whether of wood or iron, will ever be fired at the "Warrior's" armour plates, so long as at each end of those plates there exist fatal portions of the ship inviting to the fullest effect of almost every missile which can be fired into them. The conclusion is inevitable, that not in the central half, but in those two terminal quarter lengths,—there will be the struggle; there the slaughter, there the final, but not dubious, issue determined; so completely self-destructive are all false Principles, whether wittingly or unwittingly adopted.

It is superfluous, after what has now been so fully put before you, for me to state my own evident and complete conviction that "Partial Protection" cannot be maintained against "Complete Protection;" and as high Authority has lately declared from Parliament the disparity in numbers of Iron-cased Ships between ourselves and France, so it is hoped to give deeper effect to

that important announcement by declaring from this humbler Arena, that the Principle adopted for the ships of England *must render them incapable to support the honor of their Flag against those of France of equal force,*—except as his Country's honor was saved at Pavia by Francis the First.

Such, are the present prospects of success in this great game as opened by the players upon England's side: and, so far more prominently than ever before, are mental, rather than physical, efforts taking lead in these days in the inevitable decisions of Warfare.

Monday, June 10th, 1861.

Captain E. G. FISHBOURNE, R.N. C.B. in the Chair.

IRON-CASED SHIPS—*continued.*

The "Warrior's" Junior Sisters.—Proposal for a Proof-ship.

However painful it may have been in the prosecution of my task to bring structures, in many respects so noble as are the "Warrior" and "Black Prince," to the test of acknowledged principles, and find them fatally defective, a still deeper cause of lament arises on applying those same principles to their four smaller sisters. There appears no dispute that "Iron-cased Ships," of whatever size, must be most costly ones, and in such case it is reasonable to suppose that every study would be given to impart to them the highest qualities as Ships-of-war of which their size rendered them capable; it seems, therefore more than surprising to find the paramount quality of high speed not only not provided for, but actually provided against. For while it is quite possible, no doubt, perversely to give to the highest proportionate dimensions, even those of seven and eight times the breadth to the length, an abnormal and obstructive form for speed, we have seen that more than 16 years since it was found impossible to produce a speed-form out of proportions under six times the breadth to the length, as also that such impossibility had been both recognised and acted on in Admiralty designs, amongst others, in that of the "Warrior" herself; and it could therefore be only by deliberate choice, not error, that proportions but little more than five times their breadth to their length were selected for the "Resistance" and "Defence;" and, as if to make a low instead of a high speed, the object most obviously aimed at in these ships, this inferiority of their form has been further enhanced by providing them with a proportion of steam power inferior to that of any other ships of their class of equal size in the Navy. As in the "Warrior" and her sister, there are in these two juniors likewise the same proportion of unprotected ends covered only by the same fatal single $\frac{5}{8}$ plates, the proportion of guns thus unprotected being rather larger in these than in the elder ships. That proportion in the "Warrior"

is 6 to 13 on the broadside; but in the "Resistance" and "Defence" it is 4 outside to 7 inside the "box;" the dimensions of the ships being 280 feet of length to a breadth of 54 feet, with a tonnage in round numbers of 3,700 tons, or rather more than one-third less than the "Warrior's," but with rather less than half the "Warrior's" power, or 600 horse-power only. Thus, every defect of the larger ships is sadly aggravated in these smaller ones, without the one redeeming point of high speed; and to place one of them in diagram before you in supposed action with an Iron-cased Ship of an equal force of 22 guns under Complete Protection, would be but a repetition of the "Warrior's" case, with this addition,—that the position of the "Glory" as shown in Plate 3 figure 3 must be still more fatal, there being no superior speed with which to break away from the death-grip, in hope of returning again to the fight with better fortune; so completely in these ships is the fatal effect of false Principle provided for, not only by the weakness of construction in their two terminal quarter-lengths, and by their larger proportion of unprotected guns; but by their inability to decline engagement, and their incapability of escape from the inevitable results of their weakness, when once closely engaged.

I am aware that this deliberate endowment of the "Defence" and "Resistance" with such serious disqualifications as Ships-of-war, is attributed to an intention to employ them as Coast defences; but for any such explanation to be valid, it would have to be shown that disqualifications which would be fatal in action out at sea, would cease to be so if engaged with the same enemy near the land; and if there be one quality more than another required in those vessels to whose safeguard is to be committed the defence of our immediate Coasts, and the enormous property which frequents them, it is that of superior speed, by which to succour with least delay every threatened point, and give surest account of any trespasser within the forbidden limits. Surely therefore in such ships as these it was only as a parody on the favorite project of one of our gallant Admirals that they were built at additional expense with a form of bow for that operation of running down other ships, or "ramming," as it is termed, in which high speed is the most essential requisite.

The very recent date at which the construction of the "Valiant" and her sister has been entered on, affords hope that the similar errors which they too embody may yet come to be reconsidered, and that their completion will not be persevered in up to that point when "expense of alteration" can be pleaded for inflicting on the Country another pair of "specimens," in which most assuredly the Country will never see cause of either pride or profit if finished according to the design they are now building on. In these the paramount quality of speed has been as deliberately provided against, both by inferior form and low proportion of Power, as in the "Resistance" and "Defence," their proportionate dimensions being even less than five times their breadth for their length, with engines of 800 horse-power; and there is also reason to believe that from deficient displacement their height of ports will exhibit no improvement upon those of the "Gloire." But with 30 guns in ships of 4,000 tons, their powers of offence are an improvement on their two immediate predecessors, and it is most gratifying to observe that their two fatal "box-ends," have approached so near to the hawse-holes at one extremity, and the cabin

windows at the other, that another friendly nudge or two may cause their entire disappearance, it is earnestly to be hoped, in them and in their sisterhood, for ever. Of their 30 guns 28 are to be protected, and there can be no doubt that the weight of metal on those limited "box-ends," which is now to exclude the other two from protection, would, if removed from the inside of the ships to the out, suffice to give cover to these guns also, thus enlisting these two ships at once under our Neighbour's sounder principle of Complete, instead of Partial Protection, and then with improved arrangements for speed and displacement, they may, *perhaps*, be rendered reliable Ships-of-war.

In all past times, whether normal or transition, the measure of cost in Ships-of-war is taken at a price per gun; but high as that price must be, it is impossible to fix it in the case of any one of the three pair of specimens of which our Iron-cased Fleet at present consists. The cost of the "Warrior" is given in the semi-official "Cornhill Magazine" as 350,000*l.*, showing a price for her entire armament of 40 guns of 8,750*l.* each; but, as the price of every article is based on its fitness for its purpose, the question arises, Are the unprotected and the protected guns of the "Warrior" and her sisters to be debited alike? It is not even pretended that they can do like work; and it has been already shown that under the conditions of laws which cannot be evaded, the work of the protected guns is entirely compromised by their inseparable combination, *at present*, with the unprotected ones. Thus, from whatever point of view we regard the British principle of Partial Protection, its essential defects become so unmistakeably prominent, that, on financial as well as physical and moral grounds, the demand seems equally strong for its abandonment, and the adoption of Complete Protection in its stead.

It does come strictly within the professional sphere of a Naval Officer to note such qualities or arrangements in any class or description of ship as may best promote on the one hand, or most obstruct on the other, the successful issue of the Services entrusted for performance to himself or his brethren; but it is no part of his duties to undertake the labours of the Naval Architect, for which he is not, and is not expected to be qualified; it is, therefore, solely with a view to avoid the taunt that "it is easier to find a fault than a remedy," that I now venture, *advisedly*, to express my conviction that the material employed in the construction of the "Warrior," if judiciously applied, would have sufficed to give her every qualification of structure she now possesses for a Ship-of-war, and to have afforded besides as complete protection to her hull throughout as that which has been given to the "Trusty;" and I further believe that, without any great addition to her weights such practical invulnerability may be given even now.* I can hardly anticipate any argument to support the view that the enormous weight of those two "box-ends" are more usefully employed in providing against shot and shell *after they have entered the ship*, than in keeping them out of her altogether; and, taking into account the shot-deflection involved in the fine lines of the bow, the contents of the foremost cross bulkhead would almost alone suffice to give efficient

* Owing to entire inexperience in constructions of iron, there is every reason to conclude that many hundred tons of metal have been injudiciously and unnecessarily introduced by their Designers into the several details of our Iron-cased Ships now built or building.

protection to her foremost quarter-length. The contents of the after bulkhead would be less sufficient, no doubt, for covering her after end, but chiefly because the form given to that end has been such as to render inapplicable, as much as possible, the principle of shot-deflection. That principle has been largely employed in the similar constructions of our Neighbour, and has mainly contributed to enable him *completely* to protect his ships; the very form of the bow and stern strongly suggesting such modifications as may best prevent any direct impact; while the "glancing" of shot from even thin iron was established, now 20 years ago, by the experience of both the "Nemesis" and "Guadaloupe." The great amount of "overhang" in the after part of the "Warrior" and her proper-sister would no doubt cause too great a stress on the stern frame, were the after quarter-length in its present form to be plated; but that form is precisely what should be altered, since it now only adds to the already ample accommodation of the Captain, who, of all others, would be the party best disposed to surrender exaggerated comfort for the means of making the power of so noble a ship complete as an Engine of war.

How came the Principle of Partial, instead of Complete, Protection to be adopted?

We are told in a recent Blue Book—no doubt with perfect truth—that "great consideration" was given to the design of the "Warrior" before finally determined on, and weighty reference is also made to "the advantage of having access to those records in the Admiralty, which contain the best and most reliable information connected with the construction, equipment, and performance of Ships-of-war." Now, amongst those "records" was most assuredly our old Blue Book friend, 737 of 1850, the contents of which were the results of special Admiralty orders; and when this deep consideration was being given to the construction of the "Warrior's" ends with plates only $\frac{5}{8}$ thick, it is greatly to be lamented that no thought was given to the proof these plates had undergone with shot some nine years previous, as we should surely then have escaped all public as well as private regrets over that which is probably the most serious and remarkable error, official or unofficial, ever yet connected with designs or proposals for Ships-of-war. That "record" would also have disclosed the scale of relative resistances to impacts of shot in wood and in iron, determined by the experiments of 1849, and would probably have led to a transposition, as it were, of the "Warrior's" design, either by actual drawing or by calculation, *from iron into wood*, and thus another practical view for considering so serious an undertaking would have been presented, and that under a phase far more familiar to all concerned than could have been afforded by any study of a fabric of iron, where the study of a fabric of iron had never been even permitted before. If an actual transposed drawing had been made, the "Warrior" would then have appeared having a central "box" of half the ship's length, specially built for security against shot on all four sides, with a 5-feet thickness of solid wood, the two terminal quarter-lengths having timbers of the proper dimensions truly, but with open spaces between them of 22 inches, instead of 5, and covered *externally only* with no more

than a 5-inch plank. Even if any draughtsman could have completed such a drawing, the first bare sight of such a *lusus naturæ* in wooden Naval Architecture must have raised the reflection, Is it possible that incongruities so entirely unheard of in any frame of timber can yet assume the character of reasonable and natural conditions if introduced into a structure of iron? And after verifying the correct scale of 8 to 1 of this supposed transposition of a then completed design, a few further reflections *might* have arisen as to whether exclusive familiarity with all properties of wood were indeed the best possible claim to complete familiarity with all those of iron likewise; and then there might have been a slight movement of the hand towards the door-handle, just to peep into "outer barbarism" and see if if it were indeed so very dark a region upon such matters after all; and then, perhaps, a hesitating reference might have been made to the window, just to try if there were indeed any external light which could cast a glimmer on those further "deep considerations" so newly awakened within. But, alas! to the loss of us all, those considerations took no such practical turn; and seeing that no less than seven Admiralty generations had entirely passed away since those "records" had been deposited in their place of rest nine years before, it is more than probable, from their then great Official antiquity, that the first notice of their existence would have been that which was contained in the last Lecture I here had the honour to deliver. Certain it is that the decision for adopting the principle of "Partial," instead of "Complete," Protection is openly disclosed to us at page 377 of the said recent Blue Book of the Dockyard Commissioners, and is there stated to have been based on the solid foundation of an *idea*, that "idea" being that the "Warrior," as built of iron, could not be protected throughout her ends as well as centre without "making her very uneasy in a sea-way." But the same Book also discloses the terms of the public "tenders" which were issued, and and in them it is expressly required that, if "wood" be the selected material for any design submitted by those applied to, then the principle of Complete Protection not only *may*, but "must," and "must necessarily," be provided for; the Official invitation stating, page 20, "that in a wood ship the armour plates *must necessarily extend from the stem to the stern*, whereas in an iron ship *it might be considered advisable* to limit their extent to about 200 feet of the middle part of the vessel;" and thus, from recent Official statements, there breaks upon us, as strongly as words and facts can convey the conclusion, that Partial Protection or Complete Protection must depend,—according to Official decision,—upon whether England's future Iron-cased Fleet be based on structures of wood or structures of iron; and I need not observe that the whole subject presents no decision more momentous in all its results.

Now if there be one long-known advantage in iron which more than another might have been expected by this time to penetrate even the wooden walls of officialism, it is that "Strength for Strength," it produces lighter fabrics than wood can do; therefore, if armour for armour be spread over equal surfaces of the ends of a ship of iron and of a ship of wood, those of the latter "must necessarily" be the heaviest, and *pro-tanto* the operation must have the effect of "making her,"—the wooden, not the iron ship,—"very uneasy in a seaway."

Beyond the stated "idea," however, which has ruled the decision up to this time, not a single fact of experience, nor a word of reasoning, is adduced in its support; and surely it is impossible to allow that such a question as this should be determined on the grounds of a mere whim, as it is equally impossible not to see that no such whimsical "idea" could have existed in any mind practically acquainted with the properties of iron as a material for structures of great burthen and strength. Look at the near 400-feet suspension tubes of the Britannia and Conway Bridges, with their everlasting duration, so to speak, if only they be kept painted. Take the all but miles of such tubing which now crosses the St. Lawrence, and say how there can be stronger proof of the tenacious strength of *unsupported iron structures* than is here afforded under the constant test of unaltered form applied by means of the rails these tubes all carry. But look at the direct way in which this "idea" of iron weakness, as compared with wooden strength, is replied to in that great iron fact which at the very time of this "decision" was for ninety days inviting such loud attention almost within sight of those windows which have never yet been used to see through. The 180 feet of the "Great Eastern's" bow which hung in air during that time was equal in weight, as well as length, to an entire 50-gun frigate *suspended from one extremity only* when at her "light displacement;" and the 150 feet of the suspended stern was but little less; and yet in both cases without the strain of a rivet or a sensible deflexion of form. But where were the respective "centres of gravity" of these two masses; and what was the leverage they were exerting all that time to break off that bow and stern at the edge of those cradles over which they thus projected without any support whatever? Would the mind of any one long given to the practical study of a material capable of such proofs as these be distressed with an "idea" that the un-water-borne weight of the "Warrior's" extremities, if plated, moreover, with that lighter armour which the principle of shot-deflexion justifies for those parts, would have exhibited under any circumstances of weather any single effect even approaching to the characteristic of want of sea-worthiness? Is it not in such structures as these that the long practised and long acknowledged advantage of iron in "combining a maximum of strength with a minimum of material" would be seen by those parties accustomed to its use to have one of its most valuable—almost providential—applications; and could any such parties have ever arrived at a "decision" which virtually proclaimed that the British iron of the "Warrior" was less able to bear a necessary burthen, than the French oak of the "Gloire"? Surely we must here recognise the Carpenter from his "Established" place of power pronouncing judgment on the rival work, and rival material used, by his competitor the Blacksmith.

But I will press this painful portion of my task no further; I feel that I have already fully established the error itself, as well as shown its inevitable results; and now I have traced it to its *acknowledged cause*, as those whom it may most concern will best be aware, with none other than a motive to public advantage; and none the less so because for near two years the best of all poor persuasions were used against the adoption of those wretched cross bulkheads, with all their fatal surroundings, whether

of cause or effect, as so plainly shewn in Plate 3, and the letter-press it illustrates.

I need scarcely add that our present Iron-cased Fleet is no exponent, in the view of its consistent advocates, of what its ships *should be*, but is viewed by them as the exponent throughout, of those who have been the constant and consistent antagonists, against all structures of iron.

Is our Iron-cased Fleet to be built inside or outside of our Dockyards?

I venture to hope that the strict analogy I shall here adduce between the circumstances of the present day and those of 1845, and the course then pursued with such admirable results, may have some effect in determining this most important question in favour of a National, rather than what I cannot help regarding as a "Class" issue. In the above year, 10,000 horse-power of engines had to be built on principles so novel that no stroke of work of any description had ever been made towards the construction of what was required; and the question arose then, as now, whether the Government establishments at that time complete, or completing, should undertake the supply of Screw-engines for the Navy, or whether, on the other hand, the Engineer talent of the Country should be engaged for the purpose. If the former plan were adopted, then there would be years of novitiate experience to be undergone by the workmen and overseers selected from such skilled labour as could be found in the Establishments then existing, added to such as could be lured from private factories; and during the organization of these elements into such effective bodies as the private factories already possessed, every machine made, however imperfect, must be made the most it would admit of, however little that most might sometimes be. Then the Government would at once become the competitor of all the manufacturers, who would seek for orders elsewhere, and be exercising all their talent in mutual emulation for the benefit of every other Navy than their own. Then the Government would be depriving itself of the benefit of that far larger sphere of experience which each day would furnish to the manufacturer and his connexions; while the improvements suggested by the more limited service in Ships-of-war would alone supply the means of advancement towards perfecting the machinery of the Navy. Lastly, in time of pressure there would at least be wanting that cordial and common effort to relieve it, which constant and mutually advantageous intercourse would have purchased at a truly cheap price if the latter plan were chosen.

These main considerations happily turned the scale in favour of this latter plan; and great as has been and still continues the cry for "more steam," the supply is of the very highest quality produced in all the world, and the Branch Department which superintends it is approached by few, and surpassed by none under Government control, in its organisation and complete efficiency, as witness the unmistakeable proof—that it is never heard of. It has at its command, as it were, every important Factory in the kingdom, with its Chief and its entire Staff; there is no improvement whencesoever arising but is at once submitted to its notice; there occurs no difficulty, and no desideratum within the Navy itself, but many are the ablest heads which a once are at work to relieve or supply

it; and whatever other pressure may be hard to meet in coming time of need, the hardest which can be put on our machinery wants, whether for production or repair, will be met with a cordial unanimity of effort precluding all apprehension; all Government Factories being limited to repairs alone; but having extended means to enable the Manufacturer to send there his own men in aid of repairs to his own engines, whenever emergency requires.*

The analogy of this state of things to our inchoate work of producing a Fleet of iron is so close, that I will not presume it necessary to apply it, but will only observe, that in many cases there is not only analogy but identity. Every day is showing the advantage of combining the two professions of the marine Engineer with the Builder of the ship to be engined; and already more than one such double Firm has long contributed its engines for the Navy. There is, I know, in the Blue Book quoted, as strong an adverse feeling to what I have here designated as a National effort for the construction of our "Fleet of the Future" as could be expressed under the circumstances; and it is still more painful to notice a desire to support this feeling by expressions tending,—of course unintentionally,—to convey doubt on more than the capacity of Private Firms which might be employed on such constructions. But the claim thus severely to judge rivals will never be admitted by any who, like myself, have enjoyed the equally high privilege of such friendly intercourse with those on both sides of the Official wall; and certainly no support to a claim of unrivalled superiority can be established by those grave errors I have in these Lectures felt it a duty to exhibit. In those errors I desire advisedly to point out that no *unofficial* element can be made in any way to share. It has been strictly an Official, and professional, but a very lamentable and serious oversight; and, though it be true that many of the designs submitted from private parties also exhibited the same error, yet those designs were all framed under "conditions" which the Blue Book shows to have all but imposed it; and in any case, all were entirely rejected in favour of that particular one on which the "Warrior" has actually been built, and which we are expressly told is of official origin only, *and moreover, that it was completed before the private designs rejected were even asked for.*

A Discrepancy.

At page 20 of the late Blue Book reference is made to an Official correspondence on the subject of "Iron-cased Ships," which took place "in 1858," and I am commissioned on the part of my friend, the Lecture No. II. delivered on the 18th of March last, to express its high satisfaction in the agreement of the Blue Book, thus far, with its own statement that on the 10th of December, 1858, there arose an Official correspondence out of which grew the "Warrior," and all the British-born iron family. But my friend,—in whose correctness I take a great interest,—desires me to bring to notice that this correspondence of the 10th December, 1858, was

* As great additions must be made in every Dockyard intended for even the repair of Iron-cased Ships, it may be found desirable to build within these Establishments to the limited amount requisite for retaining in hand a body of experienced Artizans.

identical in object and purpose, and was based on that previous correspondence,—and even something more,—which it has presented you with verbatim as having taken place as far earlier as the 15th of November, 1855, and out of which it told you that the said iron family *might then have grown as readily as it did in* 1858. This previous correspondence, however, Mr. Blue-Book, no doubt unintentionally, has entirely overlooked even the existence of, and refers to a verbatim correspondence of his own, of the 27th January, 1859, of which, he is pleased to state, in respect to the "Warrior" and her progeny, that it "will show exactly what course was taken from first to last." "Not from the first," says my friend the Lecture, "whatever it may 'show' of the 'at last;'" and I am desired to add, on the part of my friend, that should this public though amicable challenge against the correctness of Mr. Blue-Book's rather forgetful statement, in any way "disoblige" himself or his friends, Mr. Lecture, *with equal publicity as before*, will be prepared to give more of the same verbatim correspondence in confirmation of that first portion which he had the honour to put before you on the 18th of March.

The Shield-Ship of Captain Coles.

We have all been so lately and so lucidly treated to a full explanation of the very original, and, as I believe, most valuable Invention of my gallant friend, that it would be but impertinence were I to do more than wish it a most cordial "God speed" towards an early and complete success; to which I should feel it my duty, were it in my power, in any degree to contribute. Its chief excellencies, as a proposal, consist, to my view, in its capabilities as a complete ship of any, or of every, form and size.—In its system of armour more complete for every protective purpose, with arrangements admitting of its being lighter in itself, and more safely and easily carried as a burthen to the ship, than in any other plan I am acquainted with; as it is also the only plan I know of which at all comes into conflict with my own views that armour ought not to be carried as a separate coat-of-mail at all, but should rather be embodied into the fabric of the ship herself. The whole success depends on the practical working of the shield itself, which certainly presents to my view no *primâ facie* difficulty, and is to be proved, I am happy to say for once, on a scale constituting an undoubtedly true experiment. On this point, however, as on many others not now contemplated, the whole scheme,—which may prove to be a very expansive one,—will be found no doubt to teem with difficulties, upon which strong conviction of my own I beg to congratulate my friend, because, could he produce to us an invention free from such earthly conditions, it could surely find no practical fitness where even the bread of life itself costs so many aching as well as sweating brows. But in all his difficulties I desire here to bespeak as large sympathy and aid as I may, under a feeling, of now many months' duration, that Captain Coles' invention presents the most hopeful plan yet made public wherewith those who sit to the Chess-board on the British side of the game may expect to give ultimate "check" to our astute and determined Neighbour.

The Angulated Plates of Mr. Jones.

Although as an invention Mr. Jones's plans may not be spoken of in equal terms of laudation with those of Captain Coles; yet of himself no Englishman should speak in other than terms of high commendation and respect for the public devotion, which led him, at private expense, to force on the notice of still recusant Authority the very important principle he adopts. No one can look on a piece of personal armour of other days and fail to perceive how angulated sides and curvilinear ends were then studied, as the means of rendering the burthen as light, and yet as efficient as possible against the impacts it was intended to make harmless; and if there be one thing more than another which distinguishes in form the British official effort to produce "Iron-cased Ships," as compared with those of our Rival, it is in the entire ignoring of that principle of Shot-deflection for the protection of ships, which in days of yore was studied as the lance, and the sword, and the arrow-deflection, for the better safety of persons. By Mr. Jones's truly valuable experiment, however, and by the strong feeling of its importance, with which the results impressed the Experimenter himself, the true practical character of the principle has here also been fully established; and there can be but little doubt and every confidence, when England's true international position in Naval matters comes to be more generally felt and acted on throughout the Country than it now is, that Mr. Jones himself will come to be more worthily recognised, as well as the important principle he has so patriotically forced into notice.

Experiments.

Throughout the series of these Lectures, the term "true experiment" has frequently occurred, and the time has now arrived when it behoves to offer an explanation of its use, which I beg to do in the first instance negatively. I hold that it was no true experiment to erect at Woolwich, in 1856, a 30-ton combination of wood and iron, which was driven before each shot at every round fired, and the results declared to have been such as must have been equally produced on the 1,700-ton floating mass of the "Trusty." Why? For no other earthly reason than because living men fired the gun before live spectators, with true gunpowder and real shot. I hold that it was no true experiment to erect at Shoeburyness, in 1859, another combination of wood and iron of unknown weight, said to represent the plated section of a 50-gun frigate, or say a floating mass of 3,000 tons, but the corner of which combination I laid hands on, and got up such an oscillation throughout it, that with a longer effort I doubt not I could have levelled this "target" on the sands by my own strength; yet the results of firing at this gallant structure too, with shot and shell from the Armstrong 80-pounder and other heavy guns, are doubtless amongst the accepted Official proofs of the prowress of guns *versus* armour-ships. I hold those to be no true experiments which have recently and are still being carried on in the same celebrated locality, by a Committee whose labours have been more than once loudly boasted of in high places, as likely to prove of important national benefit in solving the knotty naval problems of the day; and yet a main portion of those labours have con-

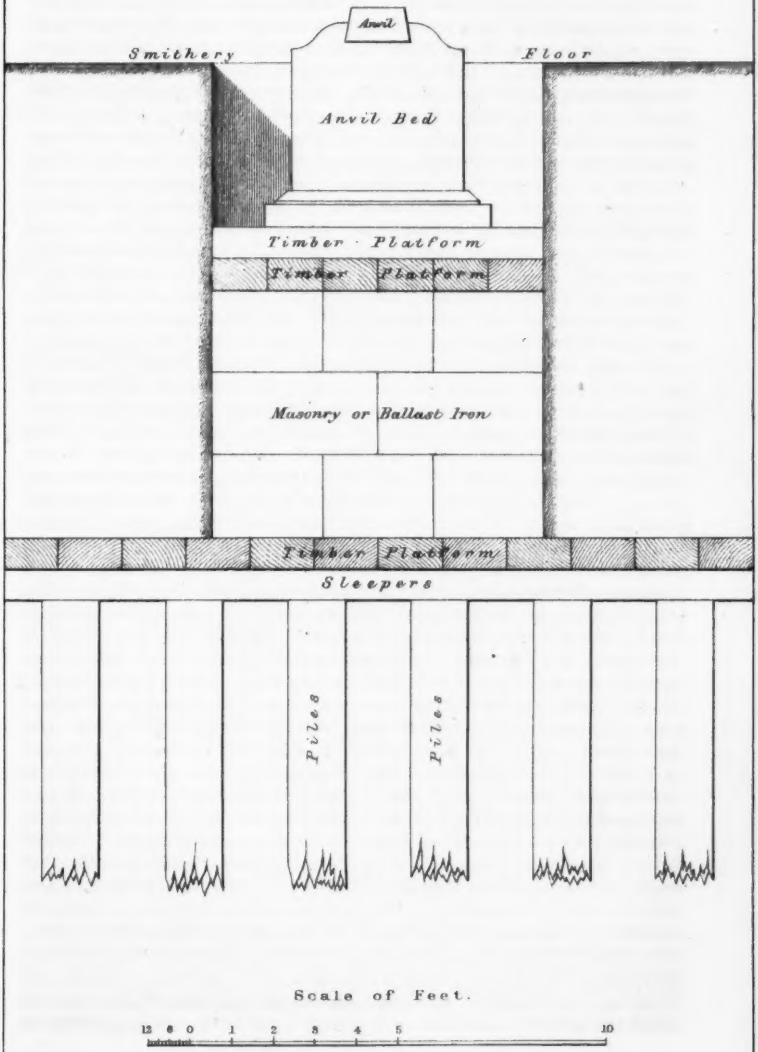
sisted in firing little else than small arms with a 5½ oz. shot against correspondingly Lilliputian plates, all to be placed under high magnifying power, so as *truthfully* to apply to the 4,000 and 6,000 ton armour-ships of the future—most probably to the great Chatham "Achilles," with a displacement of 9,000 tons. Such Committees, so employed, seem solely designed for the undignified duty of "stalking horses," to cover the crotchets past, present, or future, which find Privileged acceptance; and the labours themselves seem likely to take class ultimately, in truthfulness, if not in mischief, with the standard official experiment of the "Ruby."

Again, it has been formally laid before Parliament, as one of the results established by the Committee of 1848, that at 15 years of age wooden ships of war require "very considerable repairs," and that the average age at which wooden ships are "broken up" *is 37 years:* yet the ages of those ships which for these three years past have been selected for those *true experiments* still adopted as safe guides to all Official conclusions on the great case of Armour *versus* Guns, stand thus: "Alfred," 50 years; "Sirius," 48 years; "Undaunted," 54 years; "Briton," antiquity unknown, not being recorded in any known publication; while, as to the most recently-proposed victim, the old "Hussar" is only brought to notice before the said Committee of 1848, as being then a receiving-hulk long since condemned as unfit for movement from her moorings. Now, hark to the cries of poor old "Sirius!" as compared with human life, now verging to her hundredth year, and who, when actually young, must have been shaken to death by her own guns if made to fight an action of 4 hours' duration with 32, instead of her own 18-Pounders. "In some parts the shot has driven a portion of the armour plate before it through the ship's (port) side, ripping up planking and ends of beams in its progress. In other parts it has failed to penetrate the plate, but has driven it inwards, carrying before it a good portion of the ship's timber and planking." Listen to the operations performed on her starboard side: "Not only does the projectile penetrate the iron, punching it out, or grinding it up, but the concussion on the timber within is so great that the destruction to the ship's sides, her planking, ribs, beams, and iron-work, is threefold that which would be made by any ordinary round shot on unprotected timber." See, again, how it fares with even the "new wine" itself, when thus put into these "old bottles." "The long plate of Messrs. Beale had 10 shots more or less effective, some breaking the plate, some penetrating clean through, others tearing away with them large fragments." Now, I say that the Slaughter of the Innocents was no cruelty compared to all this; and what result, it may be asked, has been derived from thus forcibly destroying these reverend and more-than-octogenarian old frames? Verily, we have had our reward. These so-called experiments have afforded, from their earliest period, and they even continue to afford still, convincing conclusions *to those who thus seek for them*—that "Iron-cased Ships" are a folly, as half-a-dozen cases can be and are constantly quoted, wherein plates, sides, and all, are thus driven into splinters before the solid shot of that terrible "smashing" instrument, the 95-cwt. 68-pounder. And when, in spite of these strong incentives to Official inaction, the Public Common-sense outcry for such ships must indeed be yielded to, then, by virtue of these same *proofs*, 4½ or 5-inch plates—

some even go so far as to say 6, 7, and 8-inch—are fixed on as the minimum thickness of armour which could be expected to keep out even ordinary shot *if only fired in broadsides;* and to such extent have the minds of otherwise sound-judging men been carried away by the noise of these bombastic feats of artillery, that I am well convinced the "Trusty" herself would never have been fired at all but for the blind confidence produced by such spurious trials that the new Rifled Gun would have sent its shot through and through her also, like so much pudding, and thus have summarily disposed of the great "Armour case" and all its trouble. For the grounds of which conviction I venture to advance this challenge—that while records and publications, official and semi-official, are found teeming with lithographs and photographs, all taken by Official sanction, of the destruction wrought on Lilliputian or fragmental targets, or on the wrecks of the good old warriors I have named; neither lithograph, photograph, nor drawing will be found at this moment within the walls of the model "Institution" directly concerned in these matters, illustrating the results of firing on the well-backed 4-inch plates of the "Trusty," but such as have been, not publicly, but privately lodged there in order that the real knowledge to be derived from them might at least be at hand *if ever it were thought worth seeking for.* Most of my hearers, however, will, I think, agree with me that this order of almost childish proceeding has been no wise preparation for entering on the most complete and difficult of all the material revolutions in the National Fleet ever yet forced on that reluctant Authority which must work it out; and that crude efforts, when made at all, and perplexed and discordant counsels to the present time, throughout, both have been and must continue to be the natural, and one is almost tempted to add the just, reward—no less than the subject of loud national complaint—so completely have contradiction and confusion been systematically provided for.

I will now ask you just to glance at the Plate 4 before you, which represents the foundation for the anvil of a 5-ton Nasmyth's hammer: the impacts from such hammers having the closest analogy to those of shot which any known mechanical operation as yet affords. You will see first a system of 16-inch piles driven into the solid soil from the bottom of an excavation itself 13 feet deep, their heads then covered with a floor of closely packed 9-inch sleepers in a double crossed solid mass 18 inches thick; then comes a 6-feet thickness of solid masonry or ballast iron; then another solid platform of double-crossed 9-inch timber; then the anvil bed, a solid block of cast-iron 5 feet square, into a dove-tailed slot on the centre of whose surface is inserted the 10-inch anvil itself; all this massive arrangement being absolutely requisite to save it from being "smashed up" on its first turn at duty—by what? The impacts, not of the 68lb. or 100lb., or 120lb. steel shot, with a velocity of some 1,500 feet per second, but of the 5-ton hammer in its fall by mere gravitation; and yet, with so many of these well-devised arrangements known to be absolutely requisite to prevent the destruction of the many 10-inch anvils at work in every Dockyard, it is still held by the head Authority over all Dockyards, that the $4\frac{1}{2}$-inch plates on the sides of the dear old "Alfred," or "Briton," or "Sirius," are receiving all that support which they can justly require, and that their "break-up" has been, and is proof, not of

Sectional View of the Foundation or "Backing" required for the 10 Inch Anvils of 5 ton, Nasmyth hammers.



J.R.Jobbins.

their insufficient "foundation," on backing, but of their own inherent weakness, and of the superior power of guns.*

But let me add this further illustration in proof that our so-called experiments have been seriously deceptive in another most important and practical point. It is within my own knowledge that a very large Manufacturer of armour-plates was required to send to Portsmouth "for proof" certain plates, differing both in material and mode of forging; on the return Report of the respective merits of which he was informed, that while one certain plate was of high quality, another certain plate was very inferior. This naturally led to inquiry and examination, when it was found that the plates sent, having been but portions of the plates forged, the two thus reported on, instead of being plates of different construction, were, in truth, *equal parts of one and the same plate*, forged out of the same material, at the same forging, by the same forgers, but sent by mistake of his own people; and the sole assignable cause for the undoubted difference exhibited under proof was, that while one was secured to a sound, the other must have been secured to an unsound portion of those veteran sides which were taken to do duty for the "halberds" while the punishment was being inflicted. On which fact, and on the ever differing modes by which all plates are now promiscuously tried—some ashore and some afloat—I believe it would be nothing short of true Patriotism were every Manufacturer to decline all further supply of armour plates, until some common standard "Proof-ship" had been established, at which all tests could, with equal truth and fairness, be made under equal circumstances, and all results then made equally public, so that the Government, as well as manufacturers themselves, and among themselves, might know the true merits of what the one party bought and the other supplied.

It will now be readily inferred that the principle which throughout these Lectures has ruled my expression of a "true experiment," has been when negatively applied, where no single condition of the proof resembled those which actual Service must present, save the presence as aforesaid of guns, powder, and shot; such as has been, and still is, the case in all those spurious experimental instances I have noticed, and in many many more which I have not. On the other hand, those are here termed true experiments which are, or have been, made under conditions similar, or as nearly so as possible, to those which actual Service must present; the one class being nothing short of false and deceptive guides; the other class being equally safe and truthful; of which latter I will now briefly state an instance or two. I hold the Woolwich experiments of 1845-1846, though deficient, to have been true. I hold the "Simoon" experiments of 1850 to have been also sound and true, having been made on true representations, though on deficient scale, of the sides actually to come under fire in action, and oh! what a cost of every description would they have saved, had they not been disregarded in this latter day when

* While we are still using the quasi 100-year-old 19-inch scantling of the "Sirius" to prove the relative power of our plates and our guns on, those same guns, when they come to be proved on the sides of the "Magenta" and "Solferino" will meet with the same 4½-inch plates, backed on a scantling of 16-inch timbers and planking, diagonally braced within and without with iron; not 19 inches, but *three feet* in thickness.

their guidance would have proved true wisdom. Of like nature, and of like value, were the comparative experiments between wood and iron of November, 1849; all of these were, however, incomplete, but, if these two latter had been completed according to the indications they so forcibly pointed to, they would have placed us years since in that position, free from anxiety, where the heavy struggle of years to come may yet fail to find us. The experiments on the "Erebus" and "Meteor," in their limited extent, were yet true, as was also that of Mr. Jones. But the most true, and up to this time only complete, experiments made in England have been those on the "Trusty," of which I therefore propose to avail myself in this final subject-matter of these Lectures, thus:—

When the Admiralty imposed on the engineers of the Holyhead Railway those hard conditions which led to the establishment of Tubular Bridges, it was determined by the truly wise minds concerned, not to hazard a system which promised results no one could forsee how great, and how durable, by making the bridge itself *its own first experiment*, but that a true representation of it, on a truly practical though limited scale, should first be made and subjected to all those forces and conditions, the close study of which and of their effects *beforehand* should establish the undoubted laws by which not only to construct the particular bridge in question, but to establish a true system capable of any required and possible expansion. The scale fixed on was one-sixth of one of the real tubes, and the result thus wisely provided for was that unquestionable success which at once established a Principle the application of which the "New Zealander" in his day may, perhaps, see a specimen of, in the remains of a tubular bridge connecting this Island with the Continent; and such is the practical mode of well-approved procedure in which I would seek to solve the yet stiffer problems which Iron-cased Ships now present.

I submit as a formal proposal the construction of a "Proof-ship" on which to make all experiments relating to principles and details concerned in the building of our "Fleet of the Future." The ship herself to be of iron of 200 feet in length, with 50 feet beam, and having a mass displacement of not less than 2,000 tons. To begin in the middle;—I would propose the central section to be 40 feet long, built on each side over the plating of the ship proper, *with the "Trusty's" scantling of 25-inch solid timber, close covered with her hammered 4-inch plates.* The one side of this central section to be devoted to the common proof of all armour-plates on some common system duly published; while to obviate the necessity for the frequent repair of this side I would propose a level covering of 3-inch lead to be fixed over the timber, thus ensuring that every plate when under proof should be closely fitted to its backing.—The other side of the central section to be devoted to the proof of all guns and all missiles intended in any special manner for use against armour ships. And if those who now dream over the future victories of grand Rifled artillery, should think scorn of their projects being pitted against a Standard of Strength based on that of the "Trusty," I would beg to remind them that artillery, in England at least, *can bring against such standard no established solid conical or spherical shot to this day with which to violate the protection it affords;* and that when this is accomplished there will yet remain to

establish both the gun and the shot which can do it as *fit for general use*, and not for exceptional use only, before such Iron-cased "Trustys" can be even inconvenienced by the entry through their sides—not plates only—of an occasional spent cold shot. And when this again *is* accomplished, it must be shell, and not cold shot, which must break through those 4-inch plates *and then explode*, before much mischief will be done to such ships' sides; and therefore, before such sides for their *then* better protection, will have to resort to 6-inch instead of 4-inch armour for a covering; *so that the "Trusty's" practical standard is likely to last for many a year to come.** The size of this central "proof" section will admit of many comparative proofs at once.

The bow and stern sections I would propose to be of 50-feet lengths, so as to admit of high curves being used, and to be devoted to the proof of all plans for giving the best and lightest security to the ends of Iron-cased Ships, and especially to screws and rudders, whether on the principle of Shot-deflection or otherwise. There would thus remain two intermediate sections of 30 feet each, the foremost of which I would propose to devote to the proof of such modes as might be submitted for embodying the armour into the fabric itself of the ship *without any timber;* and the aftermost one to such modes of the same Principle as offered a combined strength of wood and iron together; and I desire to observe that both sides of these two sections, as well as both bow and stern sections, would offer the means of testing two distinct modes of each description of resistance. I would submit that the original construction of this "Proof-ship" be made so as at once to illustrate plans for proof, such plans to be first subjected to the close examination of a Committee, and by them selected and recommended for proof, so that experiment would commence immediately on the ship's completion. The Committee itself, I would submit to be selected by no means on the grounds of their known advocacy of common views, at least in detail. On the contrary, as true light is that combination of many colours which can never be arrived at where there is first a careful examination made to see that all spectacles have precisely the same tint, so should it be in the composition of this Committee—their spectacles might have many tints. To them should be confided the recommendation of all such further plans as might merit proof, either at public or *private* expense; at which proofs they should preside; their reports not being required to be unani-

* It is well known as being worse than useless to fire conical shells, whether segmental or explosive, against sides such as those of the "Trusty." But it is not so well known that, up to this month of July, 1861, a *conical solid shot* has as yet been "established" for the 40-Pounder (Armstrong) Gun only, and *none* for the 100-Pounder. Of these latter Guns, some 500 are made, or making; but their boastful supply to H.M. Ships is accompanied in each case by that of explosive and segmental shells only, and in no instance, as yet, by that of the only missile of use against sides of iron, a solid shot; the stores of Woolwich containing, as this note is written, *but one single specimen of the proposed article*—a round-headed, cast-iron mass of 110 pounds weight, and 7 inches in diameter, totally unproven in its effects on such sides, even if officially "approved." In order to prove it, let 50 feet of the "Trusty's" port side be unplated; all unsound timber and planking strongly replaced; all "spaces" filled in *solid* from the water-line upwards; and the plates again firmly refastened as close to the surfaced backing as in the "Warrior." Put the 100-Pounder into a gun-boat as before; use the aforesaid shot only, at 400, or even 200 yards; let the object be to knock two ports into one—the weakest spaces in the whole side—and I believe it to be very doubtful whether that object will be accomplished, or the Gun itself, in its grooving or its vent-piece—give way first.

mous; but a minority, however small, being free to express its view of the results. These results to be published by Authority so soon as duly considered, *the experiments themselves being freely open to all*, and full permission given for photographs of all actual effects to be both taken and published; the general talent of the Country being invited to offer plans, but under neither guarantee nor understanding of any description as to their recommendation for proof, or their adoption after it.

But, as a preliminary to the construction even of the Proof-ship herself, I would suggest that the experiments of 1850 should be at once recommenced on a floating target, as before, of not less than 30 feet in length, with plates of $\frac{6}{8}$, instead of $\frac{5}{8}$, thickness, and covering the frames—not of the "Simoom," but of the "Warrior;"—the spaces, however, being 16 inches, as in the iron Floating Batteries, not 22 inches, as in the "Warrior." The screen, as before, to be fixed 10 feet within the plates, but, instead of being of 1-inch fir, to be of 6-inch oak; so that every splinter passing through it must, according to the experiments of 1849, have the minimum force of a 32-pounder grape-shot fired from a distance of 200 yards with a 6-pound charge. The solid-shot 68-pounder to be the gun used, from a range of 200 yards, and, as each shot is fired, the radius of its splinters to be carefully marked out without confusion on the screen. Ten such radii, carefully referred to their respective holes through the plates, would probably suffice to ascertain the mean angle of "spread" for the splinters of this particular gun, shot, and range; and the distance *inside the plates* would thus be determined at which the solid mass of 8 inches diameter had been broken up by the impact, and its fragments dispersed to a diameter of, say, 2 feet, when it might reasonably be concluded that each fragment would possess the penetrative momentum due to its own weight and velocity only. Here, then, would be determined the distance at which to place the *inner plate*, which should arrest every splinter but those of sufficient force to pass through the screen. But if an inch, instead of a $\frac{6}{8}$, plate were used for this inner plate with the same framing as before, then many of even the larger splinters might be expected to be stopped.

I need not enter into more detail as to other guns and other shot of what was, in truth, the proposal of the Shot Association of 1851; but it is evident that this process of applying the "breaking-up" power of comparatively thin plates offers a large scope for most reliable preliminary experiments, such as must afford practical data of great importance to any Proof-ship Committee when determining the modes of structure to be recommended for those two "intermediate" sections of the Proof-ship which it is proposed to devote to plans for embodying the armour, *with and without timber*, into the fabric of the ship herself.

Let me then roughly reckon the cost of such a "Proof-ship" as is here proposed at 30,000*l.*, with an annual expenditure of 20,000*l.* for repairs; showing in five years, when her work would probably be over, a gross sum of 130,000*l.* or say 150,000*l.*; and against this I place the semi-official 350,000*l.* cost of the "Warrior;" *also, with all her sisterhood, from truck to keelson one combined mass of untried experiments*, except as to their $\frac{5}{8}$-plates; such experiments having to be proved *for the first time by an enemy*. Multiply the above sum by three, and then reflect on what has to be paid for this mode of Official "Proof-ship" No. 1. Take the

"Resistance" and "Defence" at 250,000*l.* each, and see what this mode of "Proof-ship" No. 2 must cost us. Then repeat the operation at the same price for the "Hector" and her "Valiant" sister as the description of "Proof-ship" No. 3, and the entire sum will show us not only how costly is our present mode of acquiring requisite experience, but also how dark, how dilatory, and how unpromising,—of all but expense.

Thus, so far as Official—must I say, floundering—is concerned, our truest steps seem still to be in the direction of those wooden ones, which as yet we are following on the path marked out in 1855 by the "Trusty;" and if we would indeed apply to our needs those vast Iron resources which Providence has so lavishly bestowed on us, to the envy of our great Neighbour himself as well as all other Nations, some National scheme such as that which is here but loosely sketched seems called for for the purpose; since most assuredly it will be by National effort that the 2,000,000*l.*, the price of our three present modes of unproved and all but unprovable "Proof-ships," will have to be paid.

In thus completing the Series of Lectures, upon which, by favour of this Institution, I was first invited to enter, I may be allowed to revert to the very first sentence in which they commenced, where it is stated "that, whatever views and opinions are therein put forth, they are entirely independent of all connection or known coincidence with those of any Authority whatever, and that all responsibility for them rests upon myself alone;" to which first sentence I still desire to give the fullest application and meaning which any person or persons may consider to be involved in it. And, in now tendering my best thanks to the Council of the Institution for the opportunity their invite has thus afforded me for expressing those views and opinions, and for the patience with which the several Audiences have been pleased to listen to them, I desire likewise to offer at parting my humble acknowledgments to all Authors or Compilers who have so largely aided in the fulfilment of my task. To Sir Howard Douglas I may again repeat my sense of public as well as private obligation, however widely we may differ in our respective views of those valuable facts he has so studiously collected. To all Blue Books of all sizes, pictured or plain; to all Reports and Records, official and private; of Persons, Companies, or Associations; to "*Times*" and to "Hansard's," of all dates consulted; and, lastly, though not least, to the many valued and able Friends who have so readily furnished me with that information upon which was based my chief reliance when entering on my labours—to each and to all I beg to offer my sincere thanks, and have now but to announce that, having contributed this, my share of public duty towards elucidating and furthering the subject of Iron-cased Ships, it is my determination to be led by it into no controversy whatever further than shall be requisite in order to right, as far as I can, any unintentional wrong I may have done to persons, or any errors of fact of any serious moment into which it may be shown that inadvertently I have fallen.

The CHAIRMAN.—You have mentioned an experiment with respect to two portions of the same plate. Do you know as a fact which portion was upon the weak backing, and which upon the strong?

Capt. HALSTED.—I do not say even in my paper that I do. What I say is, that no other assignable cause can be given for it.

The CHAIRMAN.—But your deduction may be the opposite of the fact. Your implied deduction is, that the plate that was upon the weak backing was destroyed; whereas the plate that was on the strong backing was not destroyed.

Capt. HALSTED.—That is, of course, the deduction. I mean to say that no other assignable cause can be found for it.

The CHAIRMAN.—But the fact may be the reverse of what you suppose. The portion of plate that was upon the weak backing may have been less damaged than the portion of plate that was on the strong backing. I want to know what was the fact. You merely surmise, and draw a conclusion from a surmise. It is an awkard conclusion to come to on mere surmise.

Capt. HALSTED.—It is not a mere surmise. If you will permit me just to point out to you there is that very 10-inch plate which the 100-pound shot went through the other day without any backing. I do not hesitate to say, if it be the case that that was done by Sir William Armstrong's 100-pounder gun, with well-hardened steel shot, manufactured for the purpose, that it was nothing more than the gun which fired at the "Trusty"—not the same identical gun, because the conditions are different. I asked Sir William Armstrong at the Institution of Engineers the other night these questions: "Is your 100-pound gun at this moment above or beyond, or in any way different from, the 80-pound gun with which you fired at the 'Trusty,' and out of which you then fired 100 pound shot at 200 yards? Do you use a larger charge?" His answer was: "No—it is the same 100-pound shot." I asked, "Is your gun the same length?" "It is of the same length." Then I said, "My conviction is, that your new 100-pound gun is not so formidable a gun for penetration as the old 80-pounder gun out of which you fired that 100-pound steel shot, and which is now rejected. For this reason," I said, "for the sake of getting a larger shell, you have now adopted a 7-inch calibre, instead of a 6-inch calibre. The whole force from the same charge of powder, the same weight of shot, the same material, fired from the same length of gun, was then concentrated over a square of 6 inches—call it 36 inches; it is now dispersed over 49 inches, the square of 7 inches. Therefore," I said, "the plate has got one-third more advantage than it had then; independently of which, the fact was then that you could not penetrate."

The CHAIRMAN.—This is mere argument, and contrary to all analogy.

Capt. HALSTED.—It is a fact.

The CHAIRMAN.—I would appeal to the engineers present whether it is not contrary to analogy. I would observe, with respect to the "Trusty," that, wherever the side was of greater substance, that was the part most effectually pierced.

Capt. HALSTED.—They did not fire at those parts.

The CHAIRMAN.—Never mind whether they fired. The effect was such—I tell it you as a fact; I saw it with my own eyes. I do not know whether they fired at it; but I know they hit it.

Capt. HALSTED.—They expressly fired away from it.

The CHAIRMAN.—You are aware, if you want to punch a hole, you do not put the plate on a yielding surface. If you want to punch a plate, the more solid the structure you rest it upon, the more completely do you punch it.

W. FAIRBAIRN, Esq. F.R.S.—I think both the naval and military services are much indebted to Captain Halsted for his very valuable papers; I have not had the opportunity of being present at any of the lectures, except this one to-night, but I have read two of them, and I was very much gratified to find that Captain Halsted had taken up the subject in the way he has done. He directs public attention to a subject of very great national importance, as affecting the security of the country at large. Connected as I am with the Committee upon iron plates, I am not prepared, at this stage of the experiments, to give any information. I am, however, inclined to think that the ultimate results will be that the whole of our navy, so far as I can judge, mus tbe constructed of iron. I have paid some attention to Captain Halsted's observations with regard to the "Warrior," and I quite agree with him that it would be much better to have the armour-plates carried round the bows and also round the stern. But it is yet to be proved whether the 4-inch or 4½-inch

plates are impenetrable to shot, particularly from ordnance of very large calibre. I have no doubt, from the present improvements that are going forward with regard to artillery, that we shall have guns that will break if not penetrate 6-inch plates. It is a question to be proved, whether we may not have to increase the thickness of our armour-plates to a degree that may exceed the limits of any vessel to carry them, or to raise the centre of gravity so high as to makethem unsafe. With respect to the impact of shot and projectiles at high velocities, I am quite of opinion that it is necessary to give such an amount of protection as may be essential for the security of the ship and of those on board. Some twenty-five years ago I was in correspondence with the Admiralty, when I first commenced iron-ship building in London. I was extremely anxious to ascertain the effect of shot on iron plates; but I received no answer for nearly two years; at last I did get an invitation to attend at Woolwich. It was in Sir George Cockburn's time. I was present at the experiments then made; but those experiments were on comparatively thin plates—double 1¼-inch plates. Then we tried wood behind, and another ¾-inch plate after that, but they did not resist a 36-pound shot. The shot went through them quite easily. The Admiralty got alarmed in consequence of the number of splinters which were dispersed in every direction; they were jagged, ugly missiles. In order to absorb these as much as possible, we put india-rubber and sawdust 12 inches thick between the second and third plates. Some particulars of these experiments I have already published, to show to what extent they were carried at that time. But, until the Emperor of the French came forward with his 4 and 4½-inch plates, we had no idea in this country to make such a provision with regard to the safety of vessels. I still hope that the Committee with which I have the honour to be connected may be able from experimental data to give the law with regard to the thickness of plates necessary to resist projectiles at all velocities. I may add, as a member of the Committee, that in conducting the experiments now in progress, they are most anxious to arrive at results calculated to increase the efficiency and security of the British navy.

Commander ROBERT SCOTT, R.N.—As Mr. Fairbairn has said, we cannot but feel greatly obliged to Captain Halsted; and if others would come forward and speak in the same open and candid manner, the difficulties in which the iron-plate question is at present involved would be soon cleared up. The plate committee's having begun with very thin plates has been commented upon, but it is surely the best plan to commence thus, and to go on gradually increasing the thickness of the iron. I need not go further into this, as the committee's plan is one which I think most will admit to be likely to produce definite results. Captain Halsted has spoken of the effects of two Armstrong 100-pounders of different sizes. The one is of 6 inches bore, and formerly threw a 100lb. shot, and was fired with 10lbs., and sometimes with 12lbs. of powder, but it now fires an 80-pound shot, and is called an 80-pounder. The other gun has a bore of 7 inches, and a charge of 12lbs. of powder, which is occasionally increased to 14lbs. Supposing that both these guns of 6 and 7 inches calibre, respectively, fired 100lb. shot with 12lbs. of powder; the velocity of the 7-inch diameter shot would be greater than that of the 6-inch, from the larger area of its rear for the powder to act upon; the present 100-pounder is, however, a more powerful gun in every way than the old one; but in both these guns, as in all the finely-grooved ordnance, a great portion of the force of the charge is expended in forcing the lead through the grooves. There is now a new gun with three grooves, called the Shunt, which is also on the compression system, but the friction being on three points only, and the charge of powder 18lbs. for a projectile of 120lbs., very destructive effects are produced by it on iron plates. In the recent experiments the shot from this gun are said to have not only broken the 8-inch bars of the Thornycroft embrasure, but also cracked the 10-inch bars, which had previously resisted the fire of the smooth-bore 68, and the Armstrong finely-grooved guns. But the conditions under which the firing took place against these bars, and that which would be the case against a ship's side, are really very different. And I do not think that any just conclusion can be arrived at from this experiment, for the dovetailed bars rested upon a solid foundation, being built up perpendicularly, layer upon layer.

The CHAIRMAN.—Not backed nor supported?

Commander SCOTT.—They were supported by iron bands and fastenings behind.

Captain HALSTED.—No backing in the shape of timber?

Commander SCOTT.—None. These bars, having little elasticity, were soon broken by the shot from the Shunt gun, which was placed exactly opposite, so that they

were hit with the full force of the shot at right angles. On the other hand, a ship is always in motion, and will be seldom if ever struck so advantageously, and a ship will always have a large amount of elasticity; and should the side be sloped inwards it will be impossible to hit it perpendicularly to the plane, with an elongated shot. With the round ball the case will be somewhat different, for the round ball rolling over in the bore, leaves the gun rotating, and will thus fall down upon a sloped side; and, although its penetration into iron is less than that of the flat-headed projectile, it causes more destructive effects to the structure covered by the plates.

In some of the Shoeburyness experiments against a casemate protected by iron, the rear was found to be very much shaken after the firing of the solid 68-pound round balls, although the previous practice with the elongated projectiles had only injured the plates in front of the casemate. And it is well to bear in mind, that in the cutting of an iron plate by a flat-headed projectile, a great portion of the force of the blow is absorbed, and hence less concussion is produced than with the round ball, which has also the advantage of a much greater velocity within the distances for effective warfare at sea. The experiments against the "Alfred" and "Trusty" are a good illustration of the remarkable differences in the effect of round and elongated shot. The "Alfred" was fired at with round shot, and, having personally examined her, I can vouch for very good oak having been smashed behind the plates, in fact two ports were knocked into one, and the whole side of the vessel badly shaken. The "Trusty," on the contrary, was comparatively little shaken, because the elongated shot pierced the plates; but I feel satisfied that if a concentrated broadside of 68-pounders were to be fired at a short distance, the "Trusty's" side would be smashed in. At close quarters, the smooth-bore 68-pounder has a very decided advantage over the finely-grooved 100-pounder, for it can be fired far more quickly and with greater safety; and depend upon it we shall always fight at close quarters. Take away the dash of our seamen, and the perfect confidence with which they rush into a hand-to-hand fight, and where will British naval superiority be? Therefore let our vessels mount the well tried 68-pounder with its simple round ball, then concentrate the fire, and I feel sure that no iron plates hung upon an upright side will stand more than two broadsides without coming down. I now wish to mention how, in my opinion, the present vessels could be rendered available; but I desire first to again bring before you, that unless the outer surface of the fortified vessel yield to or absorb the blow, the force exerted must be transmitted to the structure itself. This indicates the necessity that exists for breaking as far as possible the contact between the bottom or vital part of the ship and the top-sides. And in my opinion it shows, that, were a vessel to be wholly built of iron of 6 or 7 inches in thickness, the bolts uniting the iron planking would be broken by the concussion resulting from the blows of broadsides, or even from a succession of single heavy shot; and that the vessel would be soon shaken to pieces by the excessive vibration produced by such hammering. What I would propose is, to have iron sides built up upon ribs fastened together at the bottom and on the inside of our wooden liners, which should be first cut down to the lower port-sill.

Capt. HALSTED.—Cut the lower port-sill out?

Commander SCOTT.—Cut the vessel down to the level of the lower port-sill, and then bring the iron ribs to rest upon a bed inside the vessel; this would leave the full breadth of flotation, and keep the weight inside, giving iron top-sides with the advantage of a wooden bottom. The ribs to which the iron planking should be fastened would rest upon the keel and bilges, with a spur or flange thrown over the whole length of the upper edge of the wood, so as to effectually cover and protect it. From this spur the iron top-sides should be continued upward with considerable convexity, becoming gradually thinner as they sloped more and more inwards, but from the spur downwards a considerable thickness of plate should be used. Iron being nearly as good a conductor of vibration as of heat, an elastic or fibrous substance should be placed between the iron ribs and the plating or planking, and also between the iron ribs and the wooden bottom; these ribs, being firmly bolted together, would establish a continuity of vibration which would be expended round them, and thus prevent any heavy jar or concussion from falling upon the wooden bottom. As to the effect of artillery upon this structure, the weak molten iron shell would not penetrate the iron top-sides, nor set the wooden portion below that on fire, for fire will not burn against iron, unless there be a hole through both wood and iron to cause a thorough draft. Mr. Samuda's experiments are, I think, conclusive on this point. An elongated flat-headed shot, with a shell in

the rear, would, however, be more difficult to keep out; but, although it might damage the top-side, it would hardly penetrate the thick iron behind the oak, after having its velocity diminished by the wood buffer; at all events, to do this, the projectile must strike very nearly at a right angle, which would be a very exceptional shot. Before concluding, I may venture to mention, as a proof that naval officers do pay more attention to naval architecture than is generally supposed, that the idea of placing wood outside iron occurred to a Naval Officer, and was developed into the model exhibited at the Royal Society's meeting last year; and the plan of fastening the plates by bolts along their edges instead of through their centre was also proposed by him in 1854, and mentioned to numerous friends, as well as to persons in authority. As I have seen drawings of similar plans at the recent meetings of naval architects, I think it right, in the presence of so eminent a shipbuilder as Mr. Samuda, to lay claim for the navy to some portion of what has been done, not with the view of claiming any priority of idea, but simply to show that those who have to sail and to fight the ships do get some practical knowledge of their requirements.

Mr. SAMUDA.—If I may occupy a few moments, with regard to the subject before us, it would be to speak on the general rather than on the particular detailed points which this discussion has brought up, and which principally invites our special attention. I think on the whole the remarks which Captain Halsted has made, with reference to the imperfection of a partial covering, cannot be too strongly insisted upon. The exemplifications which he has given are very good, and lead to the conclusion that it is impossible for a vessel only partially protected successfully to encounter a vessel with the same weight of metal when fully protected. A portion of the guns of the protected vessel may be, as he has described, directed to keep in check the centre guns of the unprotected vessel, and the result must be to render the unprotected vessel a complete floating wreck, by the destruction of her two ends. I think a great mistake has been made in leaving the ends of the "Warrior" uncovered, and I drew the attention of the authorities to that point in the strongest manner imaginable. I am perfectly ready to admit that no man in the three kingdoms has done more to draw attention to the importance of iron-clad ships, and to give a greater advance to the question, than Captain Halsted. At the same time, I must say, that I think he is wholly and entirely wrong in the conclusions he has formed as to the way in which the iron plates are useful in resisting shot. His conclusions as to the value of the backing in the one case, and the want of it in the other, are in my opinion radical mistakes. I believe Mr. Scott has entirely hit upon the real difference of the two experiments; namely, that the quicker velocity at which the round shot leaves the gun is the cause of the much greater destruction, in the Portsmouth experiments, than the slower velocity of the elongated shot in the "Trusty" experiments. If there were any value whatever in Captain Halsted's observations, if he had the smallest real ground for supposing that it was due to the imperfection of the sides of the ships that were fired at in the Portsmouth case, I can assure him that when I went down and examined the "Trusty," at the request of the Admiralty, with a firm belief and conviction on their part that it would put an end entirely to the necessity of building iron ships, I came back with a totally different conclusion; I came back with a conviction that we must come to nothing but iron ships in our navy. I brought back some of the backing—a quantity of stuff which resembled snuff. There was not a piece of backing of any description or kind against those plates; the wood was totally rotten; and yet the plate resisted the shot. Therefore, how could he have advocated the usefulness of backing from this case, and spoken of the plate breaking from want of backing in another case? It is impossible fairly to do so. I will not trouble you with repeating the whole case, because I have said it two or three times before, and it has already got into print. Further observation shows me that the yielding quality derived from the elasticity of wood is much greater than the elasticity of iron—the particles of iron are in so much closer contact with one another than the particles of wood, that before the iron can receive any assistance from the wood it must necessarily yield to a degree which causes it to break. Now, I think that Captain Halsted has drawn an erroneous opinion with respect to the case of the anvil. In the first place, any man who puts an anvil upon a number of piles like that (see Plate IV.) would commit a grievous error. It is found by experience, that the very best thing you can do to make an anvil last is to do away with piles and solid foundation, and lay a quantity of wood under it, not by way of making a backing to resist the blows, but by way of making such a yielding quality, in the elasticity of the wood,

that the anvil will yield to a certain extent to the hammer, and not break. It is entirely the reverse of what Captain Halsted thinks. I have told him that before, and have explained to him the error that any person would commit who should put a very firm unyielding foundation under the anvil.

Again, with the great candour that Captain Halsted has shown all through his papers, he has made an observation to-night which has rather surprised me. He spoke of a 10-inch plate being broken through by one of these shots, now no 10-inch plate has been broken through, I have attempted to explain that the whole value of a plate to resist a shot consists of its immoveability, and its immoveability is due to its weight. It is an anvil, and the shot is a hammer. Instead of being a 10-inch plate, it has in reality been nothing more than a bar 4½ inches on the face and 10 inches deep. The expense which our manufacturers have been put to in tongueing and grooving plates, to my mind, has been wholly useless. These 10-inch plates are in reality only 4½-inch by 10-inch bars, and they have a series of grooves cut out to weaken them on top and bottom, though it is supposed that the grooving has the effect of rendering the plate and the one next to it perfectly and absolutely solid. The value of a plate in resisting shot would be the value of a 10-ton anvil if the plate weighed 10 tons, and were sufficiently compact to distribute the strain of that blow to the remotest corner of the plate. But to put a number of these piled up one upon the other like bricks, gives the plate no more value in receiving assistance from the adjacent parts than a brick would have in receiving assistance from adjacent bricks, to resist being driven out with a hammer of the size of a brick. I am surprised that Captain Halsted should have put that before the meeting without giving it the opportunity of knowing the facts properly. While upon this point I will draw your attention to the subject of tongueing and grooving plates. The plates by this plan get no strength from the adjacent plates, none whatever; it is impossible to make the fit so accurate as to prevent the particles from moving against the other plate. I admit that a backing of iron would give strength to an iron plate, both articles being of the same density; but you cannot get strength from the tongueing and grooving, because you cannot get grooves to fit one exactly into the other. You have the same result from the tongue and groove as if you had a plate one-third the thickness; and if you have one plate one-third the thickness instead of a whole plate, you only have one-third the strength. Then again you weaken the plate very extensively, just above the tongueing and grooving, by the holes which you have to drill, to attach it to the skin of the vessel. You will find that for a distance of about a foot each side of the plate, or in round numbers for about one-third of the entire height of the armour of the ship, you increase materially the weakness of your armour below the strength which is due to the amount of weight in the plate itself. It is the most important mistake that could possibly be made. That mistake existed to a greater extent in the vessels which were built in 1855, when a series of holes were made along the centre of the plates in a straight line, thus weakening the plate still more. This plan has been partially given up in the present ships; but it still exists at the edges, and is increased by the tongueing and grooving in the way I have stated. Then with regard to the advantage of elasticity, I think another mistake has been made. I do not know whether it was Captain Scott or Captain Halsted, who said something to the effect that the pliability of iron against wood would give some advantages.

Commander Scott.—Not the iron against the wood, but the wood against the iron.

Mr. Samuda.—The wood against the iron has undoubtedly advantages in breaking the force of the blow. There are some disadvantages in it, but if you are bound by any necessity to have a defence, consisting of wood and iron, the right place is to put the wood in front, and not at the back.

Commander Scott.—Will you kindly mention your experiments with molten iron?

Mr. Samuda.—I made a target that represented the sides of the "Warrior" and "Black Prince." It consisted of teak 18 inches thick, and an iron plate, which would represent the armour-plate, if the "Warrior" were turned inside out. I made a hole in this plate 5 inches in diameter, and put into it a red-hot shot, as hot as it possibly could be made—so hot that it broke to pieces by the heat. I found that you could not possibly keep it alight more than fifteen minutes. At the end of that time, through the want of air, it went out. Finding that so successful, I tried the experiment of pouring in molten iron. I made it much hotter than you can ever hope to make it in shot and shell. I put it in direct from the furnace; I poured in 10 pounds of it from

a ladle. I allowed it to become perfectly solid in the teak. I laid the teak in a sloping direction so that it should contain it all. I brought the teak and the iron, which had become solidified in the hole, to the Institute of Naval Architects, and put it on the table. In no case could I burn or even keep the wood alight more than twenty minutes, or make the hole three-eighths of an inch larger than it was at starting.

Admiral Sir GEORGE SARTORIUS.—I have taken great interest in questions of this kind, and we have not touched upon the principal material point connected with the form of ships, as to whether the French are pursuing the right principles, or whether we are; but the time is too short to enter upon the subject now, and I hope in the course of a few days to publish a little work upon it.

The CHAIRMAN.—I am sure we are all very much obliged to Captain Halsted for his research. We cannot all be expected to concur in his views. I had thought of making some remarks upon what he has said; but it would not be proper at this hour to do so, particularly as I am occupying the chair. Perhaps at some future time I may have an opportunity of reading a paper on the subject; I think he has rather over estimated many things, and underrated others. I think more highly of wooden ships and less of iron ships than he does. I do not at all sympathize with the feeling that there is any danger to the country because we have not so many iron ships as our neighbour has. Let us have our men, and I will make him a present of as many iron ships as he likes. Nor do I think this country is in any danger of his effecting a landing. However, we are very much obliged to Captain Halsted. It is important that this subject should be raised and discussed, and I do not know any man who would have undertaken the amount of labour, research, and care, that he has. If I think he has taken a one-sided view, even that is necessary to bring the subject before the public. He must come as an advocate, and not as an umpire; and that he has done, and done thoroughly. I may take this opportunity of saying, that I think he is a little wrong in not giving more credit to Mr. Drake, who was the first to propose the 4-inch plate some twenty years ago.

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